

BELL LABORATORIES RECORD



A corner of the Materials Laboratory where E. A. Bacquet is operating an Emery-Tatnall machine used for making tensile and compression tests

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Microphonic Action in Telephone Transmitters

By F. S. GOUCHER

Research Physicist

A MICROPHONE has been defined as a transmitter which makes use of the resistance variation of one of its elements to change a pressure wave into an electrical one. The active element of our commercial carbon transmitters is, of course, the aggregate of loosely packed carbon granules compressed between the diaphragm and the wall of a cavity in which they are held. Other types of transmitter operate on other principles. Bell's original transmitter, for instance, reversed the action of the present day receiver and was electromagnetic in its action. The condenser transmitter, now used extensively in the sound picture industry, depends on the other hand, on changes in capacitance. Neither of these types, however, has the advantage of the high energy output characteristic of the carbon transmitter, and for this reason the latter is used almost exclusively in present day telephone systems.

To determine the nature of microphonic action in commercial transmitters, those physical changes must be studied which are responsible for the variations in resistance that take place when an aggregate of carbon granules is subjected to variations of stress at audible frequencies. The action is complex, and as yet there has been no experimental demonstration of the precise nature of the changes involved.

A study of the behavior of single contacts between carbon particles or granules under static conditions seemed a logical first step toward the complete elucidation of the problem. Such studies have been made by a number of investigators in the past, but with uncertain results for very small contact forces. For large contact forces there is considerable evidence that conduction takes place through solid material, and that variations in contact force cause changes in the area of the contact, due to an elastic deformation of the contact material. For small forces the resistance changes did not appear to bear out this theory. Since the forces holding the granules together in a microphone are very small, the applicability of such a theory to the commercial transmitter seems questionable.

There have, moreover, been other good reasons for questioning this explanation of microphonic action. It has been demonstrated, for instance, that adsorbed air films are capable of producing a marked increase in the resistance of carbon contacts, and it is reasonable to assume that they may play some fundamental part not only in the conduction of current across the contact but in the mechanism of resistance change with variation of contact force.

There is, in addition, a marked decrease in resistance in microphones

with increase in voltage, which has not been satisfactorily explained. This suggests among other possibilities that the conduction process may involve the passage of electrons across gaps of molecular dimensions. Across these extremely narrow gaps, voltage gradients of millions of volts per centimeter might be attained with the application of only a fraction of a volt across the contact, and it is now known that electrons can be pulled out of solids with electric fields of this magnitude.

Another suggestion has been that the resistance change under pressure might be a strain phenomenon. The resistance of practically all substances changes with variation of stress, so that it does not seem impossible that microphonic action might be due, at least in part, to this effect.

It has appeared very desirable, therefore, to study the behavior of contacts—particularly those between granules of microphone carbon—under conditions of very small contact force, and this work has been undertaken by the Laboratories. A technique has been developed for controlling contact forces of the order of one dyne or less either in the highest vacuum or in any desired gas atmosphere, and also for controlling contact temperature over the range of temperatures which probably covers that encountered in a microphone. Although the work is still in progress, results have been obtained which seem significant and should aid in establishing a theory of microphonic action.

The photograph, Figure 1, shows the construction of one of the tubes used in studying single contacts. Its essential features are shown diagrammatically in Figure 2. The contacts C_1 and C_2 are fastened respectively to

a movable base M and to the lower end of a silica spring of suitable stiffness. The base M is supported from the fixed frame F by two vertical platinum wires P and pulled toward the lower part of F by two stretched springs as shown. It is moved by heat-

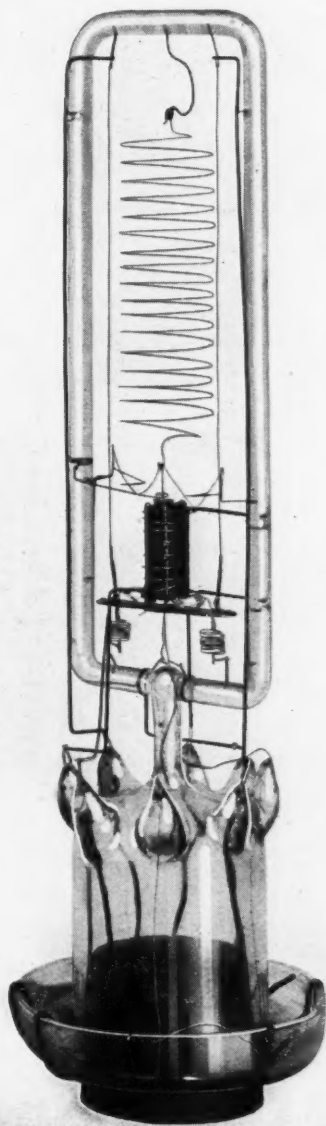


Fig. 1—One form of supporting structure for the single contact experiments. An outer glass tube encloses the structure to permit control of pressure

ing or cooling the platinum wires, thereby causing them to expand or contract. In this way the contacts may be made or broken, or any desired contact force applied through the compression of the silica spring. Control of the temperature of the contact is obtained by surrounding the con-

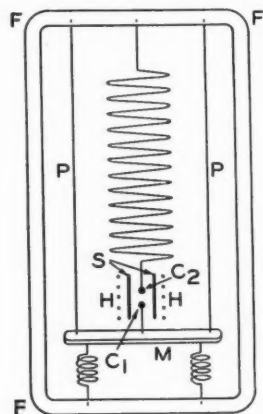


Fig. 2—Diagrammatic sketch of the arrangements for controlling the pressure and temperature of the contact

tact region with a metal cylinder *S* which may be heated by radiation from a platinum heater *H*. The temperature within the cylinder is measured by a thermocouple placed near the contacts.

In practice *C*₂ consists of a single granule fastened to the end of a platinum wire by carbon paste, and *C*₁ consists of a number of granules attached to a horizontal metal plate by the same means; in this way a variety of contacts can be studied with the same tube. A small hole in the metal cylinder surrounding the contacts permits direct observation of the contacts during measurement. Looking through this hole one would see the contacts as shown in Figure 3.

When set up for measurement the tube is suspended by rubber bands within a metal container (Figure 4)

which serve to protect the system from acoustic shock. This container is hung from a shock-absorbing suspension to minimize the effect of vibrations. Two reading telescopes are mounted in the side of the container to measure the spring compression, the lower one being focussed directly on the contact. Measurements made with this device have led to a number of conclusions regarding the nature of these contacts and their behavior when the applied force is varied.

By measurements of the temperature coefficient of resistance of contacts held together with constant force, it has been possible to identify the conducting portions of the contacts as carbon. The temperature coefficient of carbon is negative—in contrast to a positive value for metals—and this coefficient for the contacts under investigation has been found to be of the right order of magnitude and of the proper sign.

This temperature coefficient of resistance was found also to be independent of gas pressure, even though the presence of the gas was capable of increasing the contact resistance several fold for a given contact force. Gas therefore does not act as the conducting medium; the effect of ad-

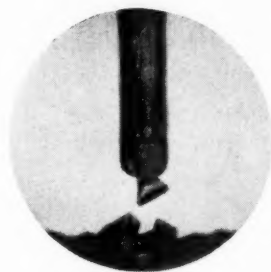


Fig. 3—Appearance of the carbon granules just before contact is made; when photographed with about seventeen fold magnification

sorbed or trapped air on resistance is merely to limit the areas of the conducting portions of the contact.

A marked decrease in contact resistance with increase in voltage—a process which is reversible—was found to be due entirely to the heating of the contacts by the passage of current. This discovery satisfactorily eliminates the possibility of electronic discharge as the main factor in the conduction process. At small contact voltages, Ohm's Law is obeyed which also is consistent with the view that conduction takes place through solid material.

Reversible resistance changes accompanying changes of contact force between fixed limits have been obtained, the resistance decreasing with increase of force. Over these reversible cycles, the temperature coefficient of resistance is found to be substantially constant as the resistance is varied over a wide range. Since the elastic deformation of a contact under pressure would produce the correct type of change in contact area to give the required resistance change, and also since a measurable change in the temperature coefficient of resistance might be expected if the state of strain within the contact region were markedly altered, both of these facts point to area change as the cause of the variability of resistance with force. Although the mean strain within the contact area alters somewhat with the contact force, even when the area changes in accordance with



Fig. 4—C. A. Bieling with the apparatus for studying microphone action between individual granules of carbon

elastic theory, the effect is relatively small.

Microphonic action, therefore, is probably the result of variations of contact area with elastic deformation of the contact material. The carbon granules may be likened to elastic spheres which flatten out as they are pressed together; the resistance decreases with an increase of the area of contact so that the current increases with it. It is possible that the stressing of an aggregate of such contacts will establish new contacts as well as change the areas of those already formed. The effect of stressing such groups of contacts also is being studied at present under static forces.

A Regenerative Telegraph Repeater

By J. H. BELL
Telegraph Engineer

WHEN a Morse key and sounder were the only means of telegraphing, the quality of the signals was not a matter of great importance. In the Morse code, which comprises combinations of short and long current impulses called dots and dashes, the dash is ideally three times the length of the dot, so that a dot could be lengthened or a dash shortened to a considerable extent without making it difficult to distinguish between them. In addition to this easily detected difference, a skilled Morse operator can generally tell from preceding and succeeding letters how to interpret a defective letter combination.

As a telegraph signal passes along a transmission line, it becomes attenu-



Fig. 1—Simplified diagram of signal distortion and of the action of ordinary telegraph repeaters

ated. For long lines, therefore, it has always been necessary to use repeaters to strengthen the signals at intervals along the transmission channel. The repeaters were, in principle, merely sensitive telegraph relays which closed the circuit of the next section of the line through a local battery, and thus sent out a new signal. The sides of a signal wave are not vertical, how-

ever, but sloping, and a definite minimum value of current is necessary to operate the repeater. As a result the period of time during which the relay remains operated is less than the duration of the original signal. This is illustrated by Figure 1 which shows an idealized telegraph signal at the left and the attenuated or reduced signal at the repeater station on the right. A dotted line indicates the current value required to operate the repeater.

The signal sent out by the repeater is shown in dotted lines at the right of the illustration. Because of the sloping sides of the signal and the minimum current required to operate the relay, the new signal sent out will be of shorter duration than the original one although its height may be the same. This shortening effect is cumulative. Each successive repeater will send out a shorter and shorter signal although in the illustration the shortening effect is greatly exaggerated. The repeater actually remains operated on a lower value of current than is required to actuate it, so that most of the shortening is on the front of the wave. Also the sides are ordinarily steeper than shown for low values of current.

Due to the large difference in length between the dot and dash, and to the ability of the Morse operator to interpret defective signals, a considerable amount of such distortion was allowable on the hand operated sys-

tems. With the introduction of the start-stop printing telegraph system* some years ago, however, the speed of sending was somewhat increased and in addition combinations of pulses 1, 2, 3, 4, or 5 units in length were

nal form as well. With this method the line may be of any length providing only that the distortion of each section between repeaters is not greater than about 40%.

The skeleton form of part of such a repeater is shown in Figure 2. It consists of a distributor having two faces, each with two solid and two segmented rings. One face is for east bound traffic, the other for west bound. In the sketch only a part of the rings are included and they have been shown flat for convenience in tracing the sequence of operations. Segments for receiving are about one quarter the length of those on the

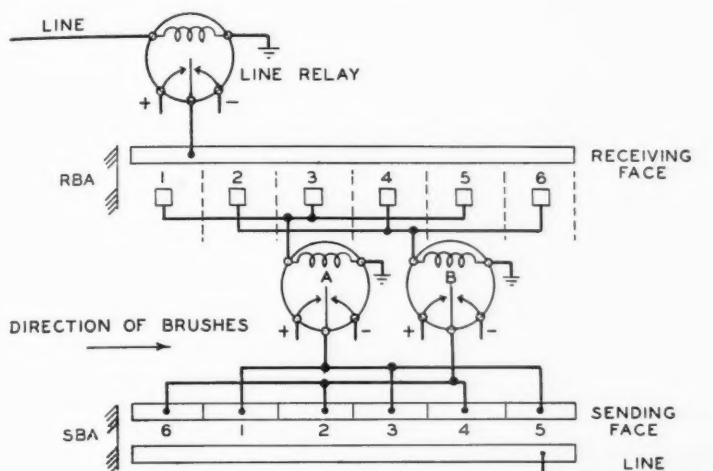


Fig. 2—Diagrammatic arrangement which illustrates the operation of regenerative repeater

used so that the situation was changed. Not only was the ratio between the length of signals decreased but the capability of the recording printer to interpret distorted signals was not so great. Although distortion up to 40% of the length of the shortest impulse can be allowed by the printer, from 25 to 30% is the practical limit. This allowance gives a factor of safety to cover variable factors such as battery voltage and line leakage.

Over a long circuit the cumulative distortion by successive line sections might render printer operation, with its stricter requirements, impossible with the earlier type of repeater so a regenerative repeater has been developed to take its place. Such a device sends out a new signal not only of full current strength but of true sig-

the sending ring, and it will be noticed from the numbering of the segments that those on the sending ring are just one pulse-distance ahead of—i.e. they come in contact with the brush one pulse-distance later than—those on the receiving ring. The receiving brush, RBA, and the sending brush, SBA, make a connection between their respective segments and solid rings as they rotate.

Each complete signal consists of seven impulses, positive or negative, sent out successively. Five of the im-

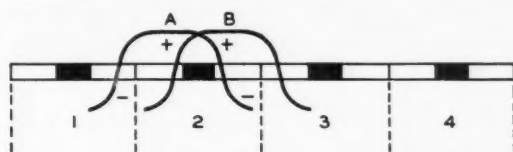


Fig. 3—The relation of incoming distorted impulse to receiving segments when the impulse is ahead of its true position (A), or behind it (B)

* BELL LABORATORIES RECORD, Sept. 1926, p. 3.



Fig. 4—Oscillograms of distorted signal received and the regenerated signal

pulses make up the signal and one at each end is required to start and stop the brush rotation. The particular permutation in which the pulses are arranged determines the signal. By the time the pulses reach the repeater station, however, they may have been displaced by distorting influence so that the impulse corresponding to the second element of signal may overlap the period allotted to either the first or third. The actual signal received during the second period, therefore, may be either part of the first and second impulses, or part of the second and third. Providing the distortion is not more than about 40%, however, there will always be a quarter period at the center of the impulse during which the received signal will be of the correct polarity. This is illustrated by Figure 3.

Assume, for example, that the second impulse is positive and that the first and third are negative. With distortion causing it to be ahead of its true position, the second impulse would arrive at the repeater in a relation to the segments on the receiving ring, as shown in the illustration at A. If the segments were full length, a positive impulse would be re-

ceived over the earlier portion of the segment and a negative over the later portion. With distortion such as to make the signal lag, however, its relation would be as shown at B. The second segment in this case also would receive both positive and negative impulses but in the opposite order. Regardless of the distortion, however, providing only that it be not greater than about 40%, the impulse received by the quarter-length shaded portion of the segment will always be positive and thus of the correct polarity.

By displacing the segments on the sending ring ahead of those on the receiving ring, as shown in Fig. 2, each signal impulse is stored up in a polarized relay sufficiently long for the relay armature to take up its position against its positive or negative contact, before transmission takes place. Relays A and B are polarized

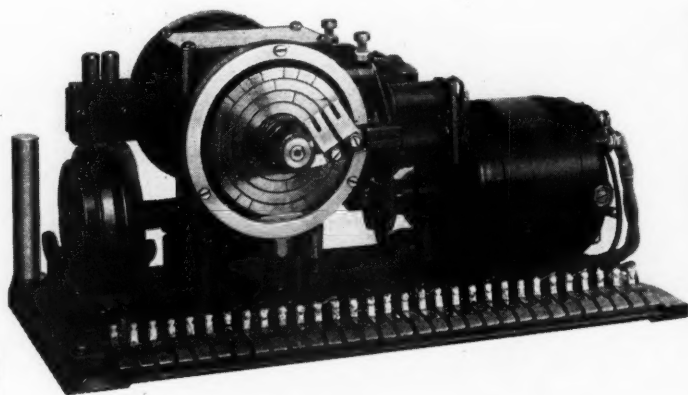


Fig. 5—A regenerative-repeater distributor

relays so that once operated they remain so till they receive another impulse. The B relay, receiving a positive impulse as the receiving brush passed over the short second receiving segment, would operate to send out a positive impulse over the second sending segment. This could not start out, however, till the sending brush reached the No. 2 sending segment which it would do only as the receiving brush was leaving its No. 2 segment. As a result a full length impulse would be transmitted since relay B does not receive another incoming pulse till the 4th receiving segment has been reached by the receiving brush, and at this time the sending brush has left its No. 2 segment.

The effect of this regenerative repeater on distorted waves is shown by the oscillogram of Figure 4. Here the outgoing regenerated signal is shown above and the distorted incoming signal below. Both the rectification of form and the retarding of the outgoing signals are noticeable. Figure 5 shows a complete regenerative repeater unit including east bound and west bound faces, and motor drive. One face backs up to the other and so cannot be seen. The solid and segmented sending rings shown in Figure 2 are the two inner rings of this photograph. The two outer rings are the receiving rings. Figure 6 is a complete regenerative repeater panel

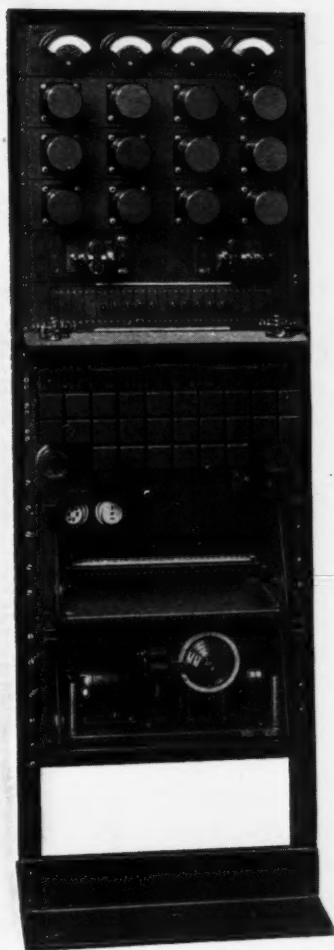


Fig. 6—A complete regenerative-repeater panel

which mounts two repeater units and accessory relays and meters.

The Ultra-Violet Microscope

By FRANCIS F. LUCAS

Telephone Apparatus Development

AS an offshoot of its development for metallography, the ultra-violet microscope has become available as a new tool for biological research. Not only does it give about twice as much detail as the best lens systems for visible light, but it largely obviates the need of staining the subject and it allows photographs to be taken at slightly different focal planes

or levels, thereby giving a consecutive record of the architecture of the cells.

Nearly thirty years ago, following the lead of Professor Abbe in matters relating to improvements in resolution by means of microscopic vision, Dr. A. Köhler of the Zeiss Scientific Staff developed the ultra-violet microscope for use in the field of biology. It had a potential resolving ability

twice that of the best optical system using visible light. The equipment was made available to scientists by the firm of Carl Zeiss and some sporadic work was done by different investigators but no outstanding accomplishments appear to its credit. Difficulty in manipulation and inability to focus the equipment seem to have reacted against the widespread use of the ultra-violet microscope.

Nearly ten years ago, following the development of high power metallography and the utilization of the full potential resolving ability of the best apochromatic systems using visible light,



Fig. 1—Francis F. Lucas and the ultra-violet microscope ready to take a picture

Bell Telephone Laboratories arranged with the Zeiss Scientific Staff to design an ultra-violet microscope suitable for metallography and for transparent specimens.

The lens system of the microscope

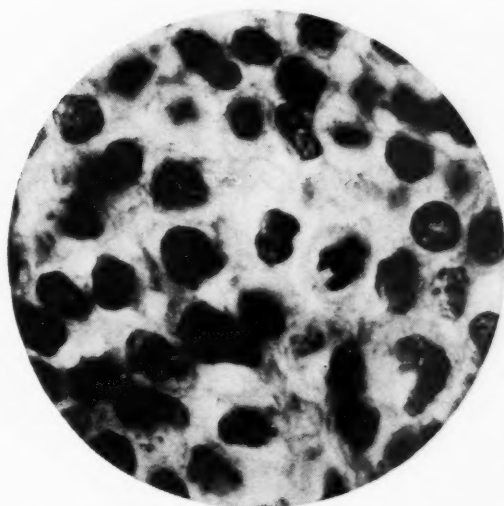


Fig. 2—Carcinomatous tissue, stained, photographed with visible light; magnified 555 diameters

is of quartz, since glass does not transmit ultra-violet light. Since it is impossible to correct the lenses for light of a number of wavelengths, quartz prisms are provided to resolve the light from a spark gap into its components, and only one of these is admitted into the lens system.

Since we are dealing with invisible light the optical image cannot be seen in the ordinary way. It must either be photographed or visualized on some sort of a fluorescent screen. The fluorescent screen takes the form of an artificial eye, which is a uranium glass wedge incorporated in a small optical system and mounted interchangeably with a camera just above the ocular. The surface of the wedge on which the image is to be received has two cross lines. These cross lines

are brought into focus by a small magnifier. Then the fluorescing image of the object is focussed on the plane of the cross lines by the adjustments of the microscope in the usual way. When the image is once in focus in the artificial eye or searcher eyepiece as it is called, the calculations of the optical system are such that it will be in focus in a plane 30 centimeters above. The camera is then substituted for the searcher eyepiece and a photograph taken.

After working with the equipment as a metallurgical microscope it soon became evident that a more exact method of focussing must be devised than the "searcher eyepiece" method of Köhler. Briefly, the focus must be exact to a hundred-thousandth of an inch. To accomplish this certain additions have been made to the mechanical system of the microscope. The microscope is fitted with a graduated half circle which has a slider, also graduated, each division equalling four degrees. The knurled thumb screw of the microscope slow-motion

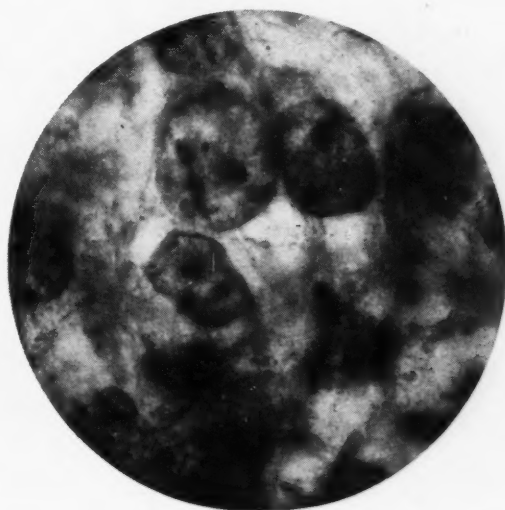


Fig. 3—Similar tissue, unstained, photographed with ultra-violet light; magnified 1390 diameters

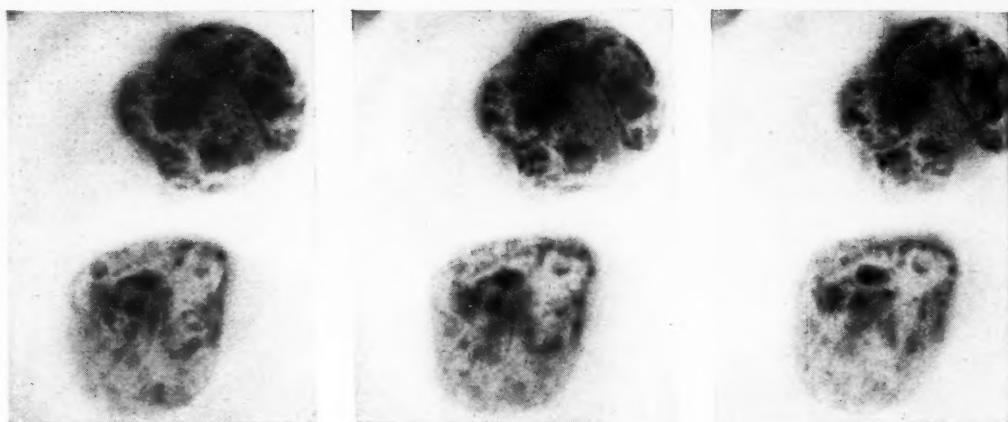


Fig. 4—Living tissue from tumor cells of a mouse, left unstained and optically

is fitted with an aluminum pointer which may be easily and quickly placed in position or removed.

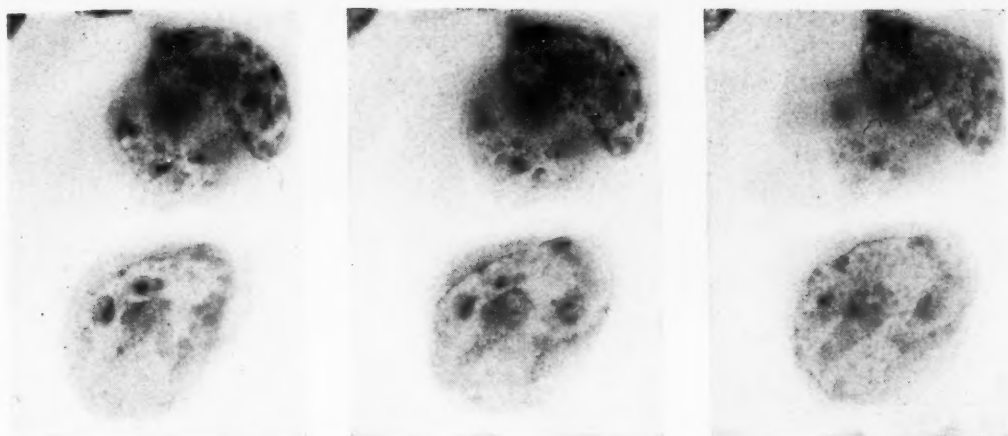
The method of operation is as follows: The image in the searcher eyepiece is brought into approximate focus by the usual methods. The slow-motion is then turned so that the instrument passes through the focus and then it is very gradually brought back. In this way all lost motion in the slow adjustment is compensated for by gravity. A very nice mechanical balance must be obtained in the moving parts otherwise the method will fail. Any "creep" or change in focus even though very slight will upset the whole method. The personnel element perhaps is still most important because the method relies on the keenness of vision of the operator to bring the image in the searcher eyepiece just to the stage of coming into focus. The pointer is then set near the middle of the scale and the slider moved so that the first graduation coincides with the pointer. A photograph is taken with the apparatus in this position; the pointer is then lowered one degree which corresponds to a change of one hundred-thousandth inch in elevation of focus, and a second photo-

graph is taken; and so on. Four photographs taken in this way of a metallurgical specimen are sufficient to provide one photograph in exact focus.

It appeared logical to assume that any optical system which will yield a very sharply defined focal plane to an accuracy of about one-quarter micron should prove to be of great value. For example, if a transparent preparation is used instead of a polished and etched metal specimen then it should be possible to photograph the details of structure on different planes within the transparent specimen.

This development has been described by Dr. E. E. Free who likens a single cell to a house; and he has imagined what he would see if the house were divided by equally spaced cutting planes. I shall adopt Dr. Free's analogy to make clear what actually does happen when living cells are so sectioned.

First we may take a photograph on a plane cutting through the attic. We do not see the roof above or the floors below. We only see the details on the exact focal plane selected. Perhaps there will be trunks, bags, boxes and things of another day placed in



sectioned by photographs at six successive planes; magnification 1600 diameters

the attic for storage. All of these things on the focal plane are clearly defined. Perhaps our focal plane cuts midway through a trunk; we do not see the top or bottom of the trunk but we see the things which are stored away within the trunk and which are intersected by the cutting focal plane. In one compartment of the trunk our focal plane has come on some woollens. We see the texture of the cloth and observe that it shows wear and then we come on the handiwork of the moth larvae. In another compartment are some queer looking sections of straw and cloth and wire and we decide that it must be a hat on which the sun has risen and no doubt set for the last time. And so we could investigate the contents of all the trunks, bags, and boxes without opening them, disturbing their contents or doing the slightest damage.

And so we may go from room to room and from floor to floor observing the life and habits of the occupants. If we take photographs as we go, the photographs taken to scale may be laid out in order from top to bottom and a working model of the house constructed.

Fortunately, our private lives are

not open to such scrutiny as the hypothetical example just cited, though it does describe on a large scale what we are now able to do with many living things.

By means of this development, a transparent specimen such as a single living cell or a group of living cells may be sectioned optically. The focal planes may be spaced as closely as a hundred-thousandth of an inch. Detail above or below the focal plane does not interfere. Successive photographs taken on planes A, B, C, etc., as illustrated in the series of photographs on the two following pages, give progressive record of the structure within the cell.

Magnifications of 3600 diameters or even higher result in crisp, brilliant images with a degree of resolution (ability to reveal line detail), surpassing by far that achieved with any other known optical system.

The method is equally applicable to fixed and stained specimens, but, except in unusual circumstances, it is always desirable to use living material. In the final analysis, biologists are interested in the structure, functions and behavior of the living undisturbed cell. Fixation and staining

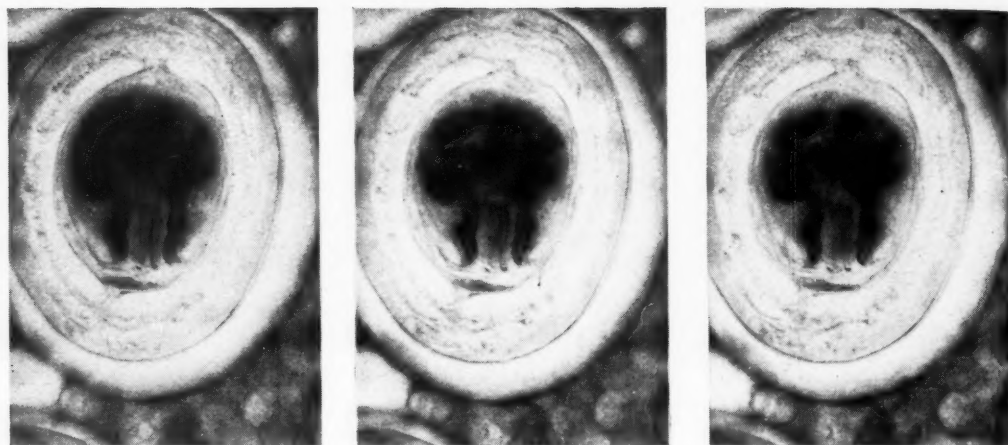


Fig. 5—Magnified 1025 diameters, a living embryo of a tapeworm was optically sectioned in these photographs. Had the mouse in whose body this embryo was

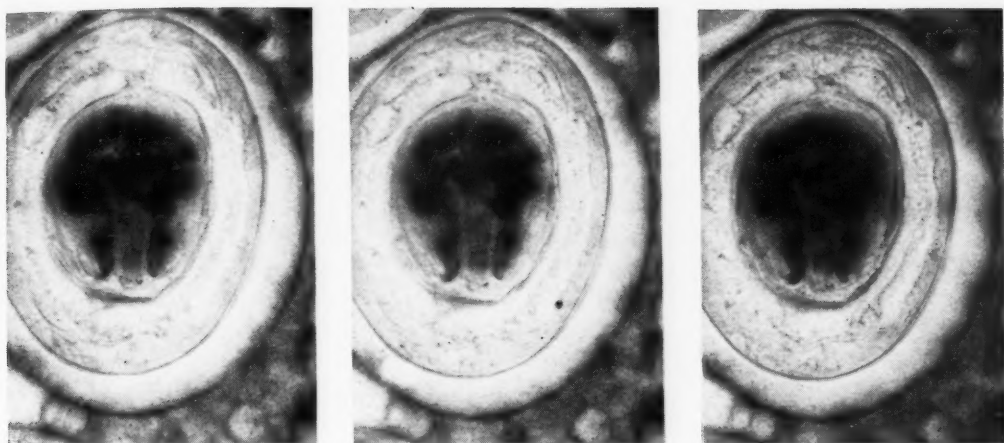
create an artificial condition from which one must reason back by deduction.

Köhler pointed out many years ago that one advantage of the ultra-violet microscope lay in the fact that organic specimens are differentiated in structure by virtue of the selective absorption which they manifest toward ultra-violet light. When using visual light microscopes, the need for staining biological specimens is too well known to need comment here. Unstained specimens respond under the ultra-violet microscope much as though they were stained. It is generally recognized that the structure of organic material is apt to be profoundly altered by the treatment in preparing it for microscopic examination. The trend in cytological research appears to be toward the study of living material thus avoiding artifacts induced by fixation, staining and mounting. The advantages of this selective absorption of organic matter for ultra-violet light will be readily appreciated if one wishes to photograph living material. There are two reservations which must be borne in mind. The ultra-violet light itself

must not have injurious effects on the organisms and the organisms must not completely absorb the ultra-violet light.

Differences in structure in living things almost always mean differences in chemical composition. For example, it is well known that the cytoplasm of a living cell is different chemically from the nucleus and when a living cell is photographed with the ultra-violet microscope, the nucleus is well differentiated from the cytoplasm which surrounds it. These, however, are gross details of structure. The nucleus contains many small bodies and usually there are inclusions in the cytoplasm. Many such details differ, if even slightly, in chemical composition and this difference in chemical composition is recorded on the photographic plate.

Ultra-violet light of the intensity and wave length used in conjunction with the ultra-violet microscope appears to have little if any harmful effect so far as many types of living cells are concerned. It is true that some single cell organisms are destroyed almost instantly; others of another species in the same mixed cul-



found, been eaten by a cat, the embryo would have developed into a tapeworm within the cat's intestines. Tapeworms are usually propagated through food

ture appear mildly excited and others immune. From some preliminary observations, it appears that living cell cultures may be exposed under the ultra-violet microscope for as long as forty-five minutes and, when returned to the incubator, they appear to grow without ill effects from the exposure.

In the preparation of the material,

I have had the cooperation of Dr. Mary B. Stark of the Flower Hospital staff and the assistance of Miss A. K. Marshall of Bell Telephone Laboratories. Dr. Stark by her skillful work and constant watchfulness of preparations has contributed largely to the successful extension of the methods developed.



Research Develops A Professional Tone

"The influence of research departments upon the character of business management has been greater than can yet be appreciated. The American Telephone and Telegraph Company has among its personnel an extraordinarily professional tone which has carried it as far along the road of good business management as the profit motive has yet carried any other organization. Mr. Gifford refers to this spirit as the body of traditions which rule the company, and accounts for it in large part by the pervading influence of their research departments. This sort of influence upon the mental habits of management is almost certain to increase as mechanization proceeds."—Henry S. Dennison in an address before the American Economic Association.

A Rapid Record Oscillograph

By A. M. CURTIS

Submarine Cable Apparatus Engineer

EVERY engineer who has used the ordinary types of oscillographs can doubtless remember times when his day was completely ruined. It happens this way. He sets up a more or less complicated circuit with two or three oscillograph vibrators connected in the proper points and after numerous adjustments of the circuit itself, followed by still more numerous adjustments of the oscillograph, he takes his oscillogram. A trip to the dark room, and fifteen minutes or half an hour later (the next day in many cases) the oscillogram is anxiously examined. In entirely too many cases it is found that something or other went wrong, the picture does not show what it was

intended to. There is no alternative but to start all over again, with the probability of a second failure nearly as great as the first.

Much of this lost time would be avoided if the oscillogram could be examined immediately after exposure, which would permit improper circuit conditions to be corrected at once. It must not be lost sight of, however, that the older instruments have several inherent defects, usually unsuspected by the less experienced engineers. One of the most important of these is that the damping of the vibrators depends on the viscosity of the damping fluid which, in turn, varies markedly with the temperature and age of the liquid. Failure to properly

test the damping of the vibrators immediately before taking oscillograms is responsible for many misleading results, the most common condition being an excessive over-damping which eliminates almost entirely the higher frequency components of the recorded wave. Also many assume that a vibrator with a certain natural frequency in air will give significant results at nearly that frequency when immersed in the damping

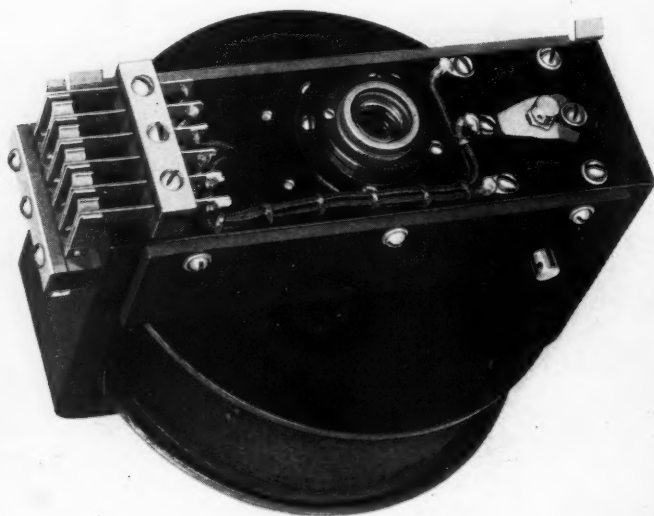


Fig. 1—Electro-magnetic portion of the Rapid Record Oscillograph

fluid, which is not necessarily true.

With these difficulties in mind, the Research Department has developed a new oscillograph which it is hoped will make oscillograms much more useful and popular in the Laboratories than they are at present. The outstanding feature of the new machine is that the picture, while its taking is controlled manually, is automatically developed, fixed, and passed slowly before the eyes of the engineer within a few seconds after the exposure takes place. The oscillogram is ruled off automatically in abscissas of thousandths of seconds and ordinates of twentieths of inches and, since it is on bromide paper instead of on sticky films, immediate measurements may be made.

The new oscillograph— an offspring of one previously described in the RECORD* and of the light-valve for sound pictures — has like the light-valve an electromagnetic field in which fine wires carry the currents of interest. There are three of these wires, and their shadows, enlarged 35 diameters, make a white trace on a moving strip of sensitized paper. The principal difference between the camera of the new oscillograph—for which we are indebted to Professor Trowbridge of Princeton and his assistant Mr. Duryea for some of the design features—and that of the older sound-ranging oscillograph camera is that in the new machine the paper is exposed at a high speed, varying from 3 to 150 inches per second, and developed at a lower and independently adjustable rate of from 2 to 10 inches per second, whereas the original machine was usually operated to develop at the same speed as exposure, the

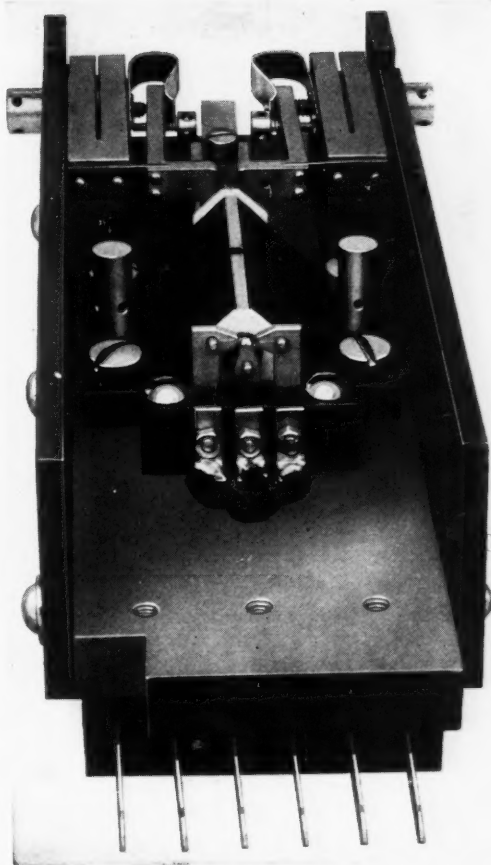


Fig. 2—One pole piece showing the three strings and the thermostatic supports that maintain tensions for all operating temperatures (approximately actual size)

range being from about 2 to 18 inches per second. The new machine permits oscillograms of varying maximum lengths, depending on the paper speed. At the maximum speed pictures two or three seconds long may be taken, while at the lowest speed as much as 150 feet of paper may be exposed, developed, and fixed.

The galvanometer of the new oscillograph is normally operated with the strings stretched to a natural frequency of 3000 cycles per second. It can, however, be adjusted to a natural frequency as low as 1000 cycles or as high as 4500, with resulting changes

* BELL LABORATORIES RECORD, March, 1927, p. 225.

in sensitivity. The damping, instead of depending on a liquid of varying viscosity, is almost entirely electrical. Tension of the string after adjustment is maintained by a miniature thermostatic element, which makes the natural frequency nearly independent of the temperature. Three strings are employed which permit three oscillograms to be taken at the same time. One model allows the center string to pass either of the side strings and to be deflected so that its image crosses the entire width of the paper, while each of the side strings can be deflected to cross half the width of the paper. In another model the strings are mounted in three planes and each image can deflect over nearly the full width of the paper. In both

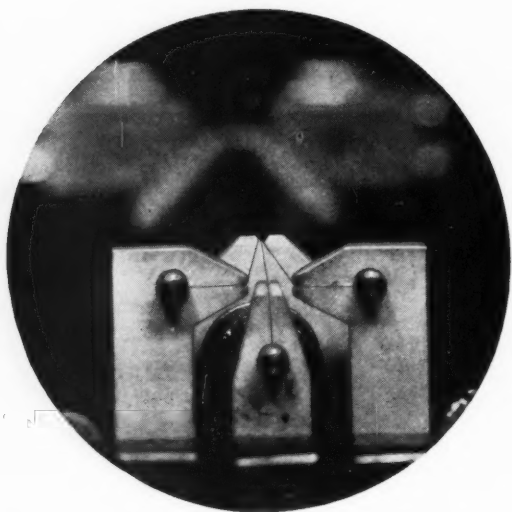


Fig. 3—A photomicrograph of the delicately constructed bridges that hold the three strings (magnification three times)

models the wires are of duralumin about .0008 inches in diameter. The construction of the ivory bridge which holds the strings required the finest kind of work by our precision shop.

One of the fundamental limitations met in the design of oscillographs is

that the sensitivity, when the effect of the damping shunt is considered, is somewhat less than inversely proportional to the square of the natural frequency. As a result, a high-frequency vibrator is bound to be rather less sensitive than might be desired. In the galvanometer under discussion, operating at a natural frequency of 3000 cycles, a current of about 20 milliamperes through 3 ohms is required for a workable oscillogram. Where only alternating currents are to be considered it is not hard to build a transformer to step up this inconveniently low impedance and to decrease correspondingly the current required. But there are many circuit conditions in the telephone plant the study of which requires that all frequencies down to direct currents must be reproduced faithfully in the oscillogram. Where currents of 20 milliamperes are not available, the only solution of this difficulty is a direct-current amplifier, and one has been designed for use with the new oscillograph.

The design of direct-current amplifiers even in their simplest form has always been a serious problem. The design of one for the oscillograph is particularly difficult because of several requirements which amplifiers are not ordinarily expected to meet. In the first place no input transformer can be used, and the amplifier must be able to operate with both ends of its input circuit ungrounded. It floats on its input, therefore, and consequently must be built with its batteries as a unit, and completely shielded. No output transformer can be employed and the impedance of the normally shunted oscillograph is only three ohms.

Because of these facts it would be necessary, if the amplifier output im-

pedance were to match the load, to use 600 low impedance tubes of our "O" type in parallel for the last stage. With a push-pull instead of a simple amplifier, which other considerations make desirable, 2400 tubes would be required. This is, of course, ridiculous, particularly since batteries to supply 48 amperes plate current and 2400 amperes filament current would all have to be contained within the amplifier cabinet.

The problem thus reduces itself to discovering how few tubes will be required in the output circuit to vibrate the string at a reasonable amplitude. On the assumption that the string would be shunted for optimum damping, it was calculated that about 16 tubes would be necessary. It was found possible, however, to reduce this number to eight by making the damping shunt part of the amplifier circuit and raising it from 4 to 14 ohms. This resulted in under-damping of the galvanometer, which led to an increase of sensitivity as the resonant point was approached, but the interstage circuit of the amplifier was arranged so that the gain decreased with frequency at a rate which just compensated for the increase of galvanometer sensitivity. In this way the combination of amplifier and galvanometer was made to have a flat characteristic up to 3000 cycles, and to have about twice the sensitivity it

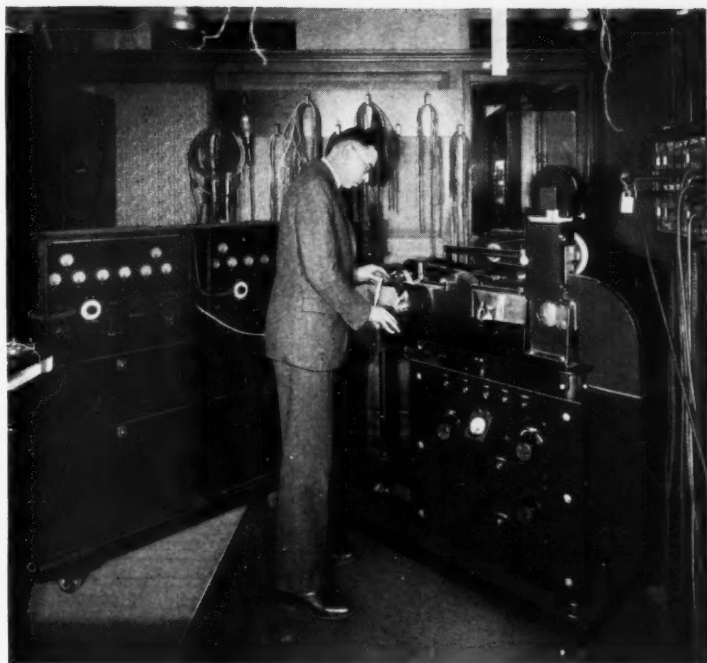


Fig. 4—I. E. Cole reading a just-developed oscillogram. The electro-magnetic unit is immediately above his left hand and the two amplifiers at his back

would have had otherwise. As an added convenience it was found possible to heat the output stage filaments by alternating current and avoid battery maintenance in most cases.

The difficulty of maintaining the stability of a direct-current amplifier increases rapidly with the number of stages and it seemed out of the question to use more than two in an amplifier for general laboratory use. To get the maximum possible gain, screen grid tubes were used for the first stage. All the components down to direct currents need not always be reproduced in an oscillogram. Many telephone circuit investigations can be satisfactorily carried on even though the frequencies below 100 cycles per second are not properly recorded. The amplifier is arranged therefore so that suitable input and output transformers can be switched

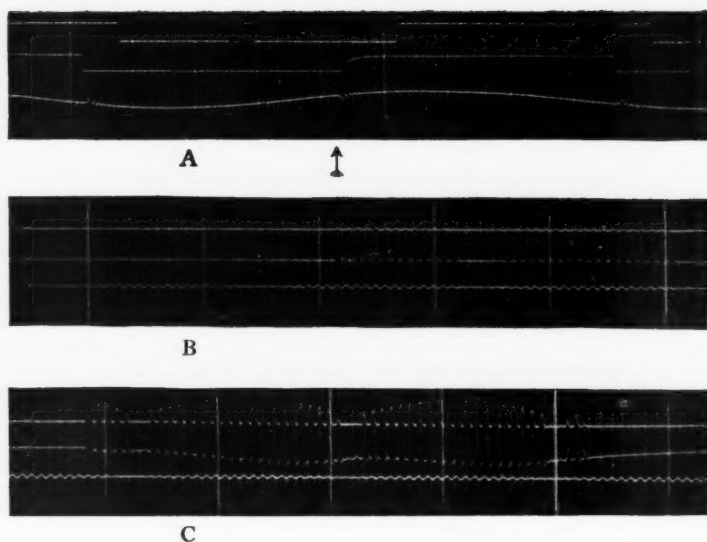


Fig. 5—Typical oscillograms showing various uses of the Rapid Record Oscillograph

into circuit and the number of tubes in the last stages reduced to two when the very low frequencies are not required. The amplifier and oscillograph combination is 100 times more sensitive when operating on the band from 100 to 3000 cycles than when used for direct currents.

To illustrate the variety of studies which may be made with this oscillograph, several oscillograms are shown in the accompanying illustration. The broader time lines are spaced .01 second and the narrower ones are .001 second apart. "A" shows the operation of a flat type relay, pulled out of a drawer at random and doubtless in bad adjustment. The lower record shows the current in the winding of another relay which controlled the current to the relay under test. The central record shows the current in the winding of this test relay, and the upper, the current from its contacts. The armature of the control relay starts to travel at the point marked with an arrow and produces the large nick in the lower wave. About .001

second later its contact closes, but the vibration of its armature continues and the current generated is shown by the damped oscillation on the lower trace. The current commences to build up in the winding of the flat type relay and reaches its maximum in about .005 second but the contacts do not close until .009 second after the current commences to flow.

"B" shows modulation between two alternating currents in a vacuum tube modulator, the center and lower oscillograph strings being connected to two amplifiers arranged for direct current operation. The increase in size of the record due to the use of the amplifier with only part of its gain may be seen by comparing the top trace with the center trace, both of which show the same current, but unamplified in the case of the top trace. The impressed frequencies were 1222 and 1168 cycles per second; the input to the modulator was interrupted by a relay vibrating about 16 times a second, which accounts for the grouping of the modulated wave. The difference frequency of 54 cycles per second is indicated by the rise and fall of the amplitude of the modulated wave, while the summation frequency of 2390 cycles shows distinctly as the ripple about the zero line of the center trace.

"C" shows the same effect but with the oscillograph strings connected somewhat differently. The bottom string as in "B" shows the current in

the primary winding of the transformer feeding the modulator. The top string was connected in the low winding of an output transformer chosen to match the impedance of the strings to that of the modulator, while a small portion of the voltage applied to the top string was impressed on the input of the amplifier connected for alternating current operation. The transformer alone passes the lowest frequencies so well that close examination is necessary to detect the wander of the zero point of the upper trace from its true position, but the failure of the amplifier to pass direct currents is made evident in the center trace by the wandering of the lower peaks from their proper position.

The phase distortion of the amplifier, a lag of about one ten thousandth of a second, can be detected by comparison of the position of the peaks of the center trace with those of the upper trace.

Many other examples could be given of the uses of the new "Rapid Record" oscillograph, such as the study of time lags and phase distortions in transmission networks. It is hoped that the few illustrations given here will suggest to engineers how the use of the oscillograph will simplify their work by making plain a good many obscurities in the operation of apparatus which, because of experimental difficulties, have been inadequately studied in the past.



Success of the Telephone Prepared Public for Radio

When the telephone was first introduced to the public, back in 1876, it had to struggle against overwhelming indifference and actual opposition from some members of the public who persisted in regarding it as a "scientific toy" of no practical value. On January 1, 1877, ten months after Alexander Graham Bell had been granted his original patent, there were only 2,593 telephones in use in the whole country. Despite this opposition and indifference, the telephone continued to grow and spread until now we have a nation-wide system and more than 20,000,000 telephones.

When the radio was introduced, however, the public response was immediate and enthusiastic, and millions of sets were in use within a very few years. But it was a very different public from that which so scornfully rejected the telephone nearly fifty years before. It was a public which had become accustomed to scientific progress and which eagerly asked for more. And the rapid spread of the telephone, once it got under way, undoubtedly helped considerably to prepare the public for radio. In 1876 men said it was obviously impossible to transmit the human voice over a solid wire. When they discovered they were wrong, they were not so ready to call anything impossible, even the transmission of the voice through space.

Springs for Telephone Apparatus

By J. R. TOWNSEND
Telephone Apparatus Development

THE many types of springs necessary to fill the manifold needs of telephone apparatus comprise both non-ferrous and steel springs, of sheet metal and of wire. Proper functioning of all these can be ensured only by care in their design and in the selection of their material. In many instances springs must occupy but small space, yet must maintain delicate adjustment, with a minimum of attention, throughout the life of the apparatus. The forces on springs are sometimes large, and space limitations require that the springs operate under comparatively large unit stresses.

By far the most numerous are the sheet non-ferrous springs, usually consisting of punched and formed parts made from brass, nickel-silver, or phosphor bronze. Some are employed statically—to maintain constant pressure for long periods—but more are subject to successive deflection, electro-magnetically or mechanically. The latter are essentially cantilever springs, clamped at one end; they are used in switchboard keys (Figure 1), subscribers' dials (Figure 2), relays, jacks, interrupters and switches. The fixed end is customarily clamped between strips of phenol fiber, a good insulator, mechanically strong, and permanent in form. When used as contacting members, they bear one or more precious-metal contacts spot-welded in place near the operating end. The precious-metal contacts are

employed to reduce contact resistance and the destructive effects of arcing when circuits are broken. When used as brushes or wiping members, the spring material itself usually serves for the contacting and wearing parts. To springs that form part of electrical circuits, the connections are soldered, usually to lugs which form part of the spring and project from it at the end of the clamped area opposite its operated end.

The properties required of these small springs are numerous and vary for each type of application. The proportional limit* must not be too high to prevent adjusting the spring by flexing it with a tool to the point where it takes a set and occupies a position in which it provides the desired operating pressure. In other words, there must be room enough to flex the spring to the point where it will take a set within the space provided. A spring of high proportional limit, such as one of clock-spring steel, may be bent nearly double without being permanently deformed. Obviously, such a spring could not be adjusted in the key shown in Figure 1.

The modulus of elasticity should be within the range of twelve to twenty million pounds per square inch in order that the load-deflection rate will not be too steep to permit reasonable ease of adjustment by hand.

If telephone-apparatus springs were

* The proportional limit is the stress beyond which deflection is not proportional to stress.

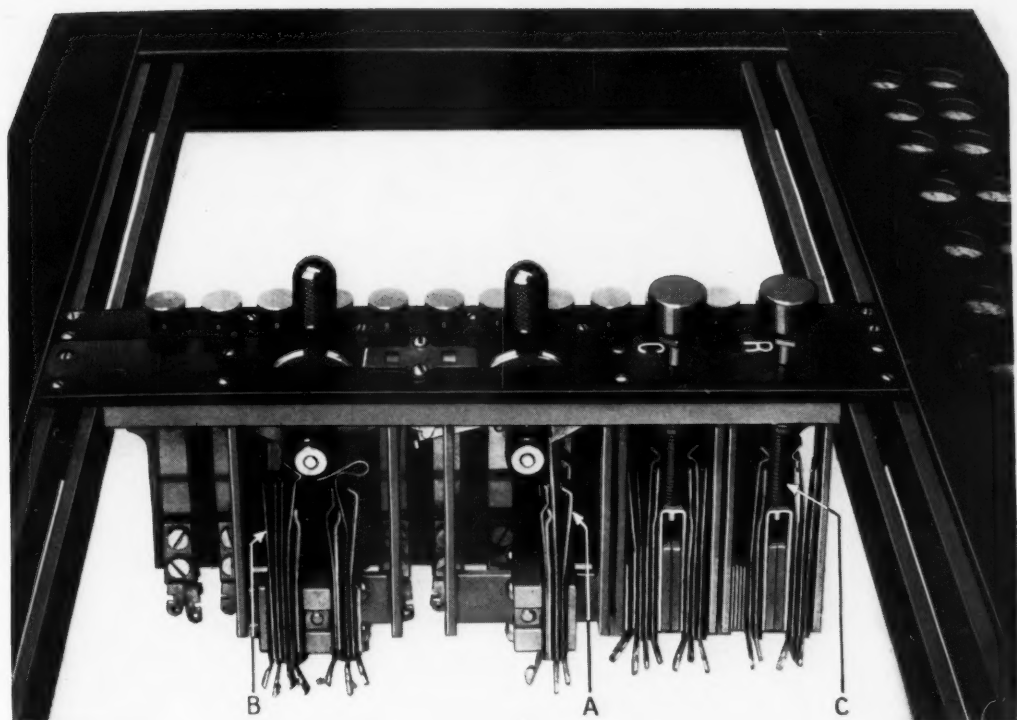


Fig. 1—Switchboard keys frequently embody wiping springs (A), contact-carrying springs (B), and helical compression springs (C)

not carefully designed to have as large a factor of safety as possible, there would be numerous cases of fatigue failure. All metals thus far investigated have an "endurance limit", a maximum stress which may be repeated indefinitely without failure. A stress above this limit, if repeated often enough, will lead to eventual failure. The effect is cumulative and the failure occurs quickly in seemingly sound metal that has functioned satisfactorily for years. Only recently, after completing a few preliminary fatigue tests on sheet metal, has the full significance of this property been realized. It has been shown that the ratio of the endurance limit to the ultimate tensile strength varies from .15 to .36 for brass, nickel-silver and phosphor-bronze sheet, and that for steel the ratio varies from .40 to .60.

It is important, therefore, to know the endurance limit of non-ferrous sheet-metal springs in order to determine whether a design provides a sufficient margin of safety.

"Creep", or deformation under sustained load, must not take place, since the material will lose tension. Brass, nickel-silver, and phosphor bronze may be expected on the basis of years of experience to hold adjustments when stressed up to approximately their proportional limits. Other materials when considered for telephone apparatus springs are investigated to determine their "creep" characteristics.

"Season cracking"*, or spontaneous failure of a metal under prolonged stress, takes place with some brasses

* BELL LABORATORIES RECORD, October, 1929, page 77.

under high sustained stress and severe atmospheric conditions, and therefore springs that are required to hold their pressure for long periods under these conditions are not made from this material. Nickel-silver will also season-crack under still higher sustained stress and more severe corrosive conditions; phosphor bronze is least susceptible of all. In designing these springs, generous fillets and easy curves are employed to prevent the building up of localized high stresses that may lead to season cracking under sustained load and fatigue failure under repeated flexure.

When springs are used as wipers in electrical circuits where arcing can occur, brass and nickel-silver are not employed because the heat of the arc breaks down the material, volatilizes the zinc, and disintegrates the spring. For springs so used, phosphor bronze, which does not contain zinc and has wear resistance superior to brass and nickel-silver, is therefore employed.

Springs must also be resistant to atmospheric corrosion and capable of readily alloying with soft solder. Nickel-silver is superior to brass in its mechanical properties, and may be readily spot-welded; as a result of years of experience it has been found that springs made of this material are capable of maintaining adjustment in a satisfactory manner in service. Phosphor bronze has still greater wear resistance than brass or nickel-silver and superior spring properties.

Springs of clock-spring steel are used as vibrating elements in interrupters, where a high fatigue endurance is required, and for springs that must be worked at high pressure and rapid build-up of pressure. These springs are made from carbon-steel, heat-treated and then cold-rolled, and are by nature brittle. To guard against excessive brittleness and at the same time provide a high strength, a bend test has been developed. It requires that when the material is bent

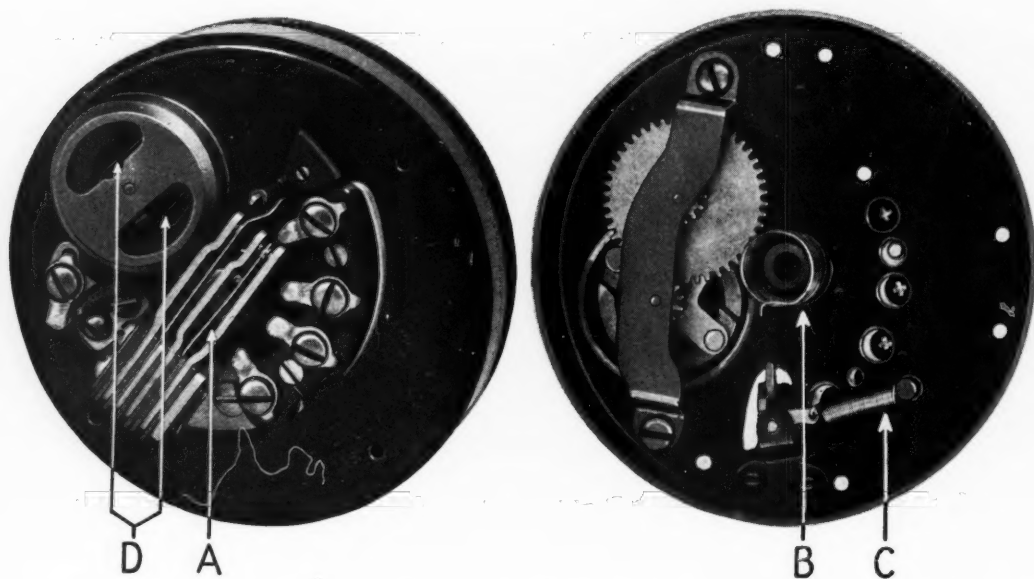


Fig. 2—Subscribers' dials contain (A) a pile-up of contact-carrying springs, helical springs for (B) motor and (C) pulsing, and (D) governor-weight springs of clock-spring steel

back parallel to itself to form a "U" and further compressed between flat parallel surfaces (for example, between the jaws of a vise), the material shall not break when compressed a certain distance but must break when compressed further. The test can be conveniently applied by drawing the looped material through two of a series of graduated slots.

Tinned and plated music wire is extensively used for compression springs in telephone apparatus. Here the spring is in the form of an open helix, and is either tinned or plated with nickel. The average tensile properties of the music wire employed are: proportional limit, 217,000 pounds per square inch; ultimate tensile strength, 350,000 pounds per square inch. No chemical or tensile requirement is placed on this wire, the main feature of concern being brittleness. The elongation measured in an eight-inch length must be between one and four

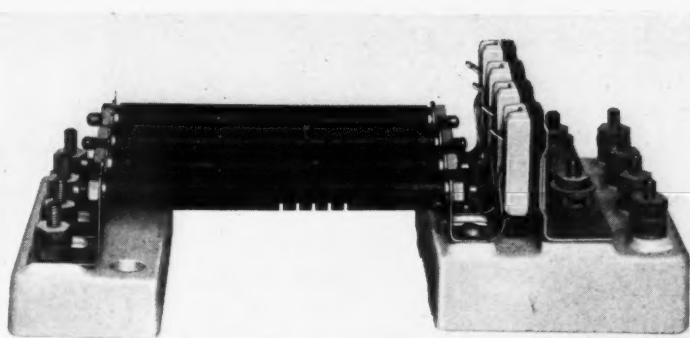


Fig. 3—In the protector, nickel-silver springs hold the protector blocks in place

per cent for heavy wire (up to and including No. 27 gauge) and one-and-one-half to seven per cent for No. 28 gauge wire and lighter. A kinking test, in which No. 30 wire and smaller shall kink without breaking, also indirectly controls its tensile properties.

Vast quantities of springs are employed in the telephone plant, and numerous factors must be considered when selecting materials for them. The materials generally used have abundant sources of supply, and the quality is carefully controlled by tests that are designed to be easy to apply and effective in evaluating the properties desired.

Central-Office Lighting

By E. K. EBERHART
Equipment Development

FOR telephone central offices two major types of illumination are required, corresponding in a broad way to two types of work being done. There are the operating rooms, where switchboards and desks are located, which require a treatment distinctly different from that needed for the switch and apparatus rooms. Here the work may vary from solder-

ing a jumper to making a delicate adjustment of a relay but there is required for the most part a rather high degree of illumination. In the operating room the light need be only bright enough to enable the operator to read the designation strips.

The provision of satisfactory lighting for the operating room has not been simple. A totally indirect system, where all the light is reflected from the ceiling would be desirable in that it would give no high intensity sources to dim the signal lamps or to cause troublesome reflections from polished or glass surfaces, but it is expensive both to install and to operate, and lacks the cheerfulness that visible light sources give. The psychological effect of a lighting system can never be disregarded. Light is a stimulant and darkness is a soporific and depressant. Also, two rooms with equal illumination intensity on the desk level—one lighted indirectly and one with direct units—will not appear equally bright. The directly lighted room will appear brighter and will, therefore, be better psychologically. Because of these facts, the system adopted for operating rooms has been a combination of the best elements of the two methods. A semi-indirect and totally enclosed unit, shown in Figure 1, has been standardized. The lower part of the translucent bowl is heavily enameled so as to diffuse and soften the light radiated downward. The upper part is flat



Fig. 1—An operating room in the Walker-Lispnard Building showing the new semi-indirect lighting units

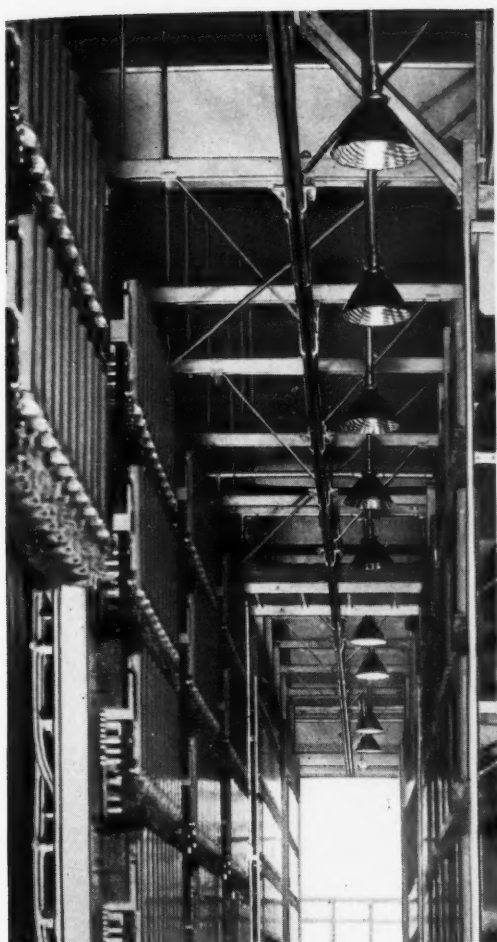


Fig. 2—In switch rooms mirrored glass reflectors are commonly employed to give the higher intensities required

and lightly etched to allow a large portion of the light to reach the ceiling where it will be diffusely reflected. This arrangement makes practically the entire ceiling a source of light, and as a result shadows are softened and made unobjectionable. The top of the unit is made flat so that no very bright area will be visible from the floor to cause glare.

Total enclosure keeps out dust and thus maintains a higher efficiency over longer period. All types of reflectors decrease in efficiency with the accumulation of dust, and with some types

the depreciation may amount to nearly 50% in a few months. It is always necessary, therefore, to establish regular periods for cleaning, but the time between cleanings may be lengthened by a proper choice of fixture.

Within the operating room the ceilings are usually fairly free from obstructions so that the use of semi-indirect units is practicable. Where there is a considerable amount of overhead obstructions, however, which is frequently the case in portions of the switchroom where the test desks are located, an intermediate form of unit is employed. An opalescent globe is used to obtain a diffused source but the indirect reflec-

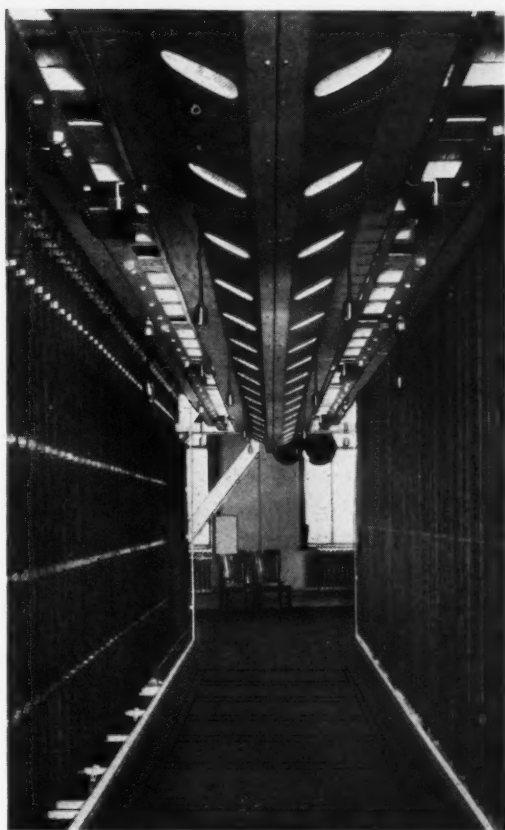


Fig. 3—Lighting for main frames combining in a very satisfactory manner high intensity with freedom from glare

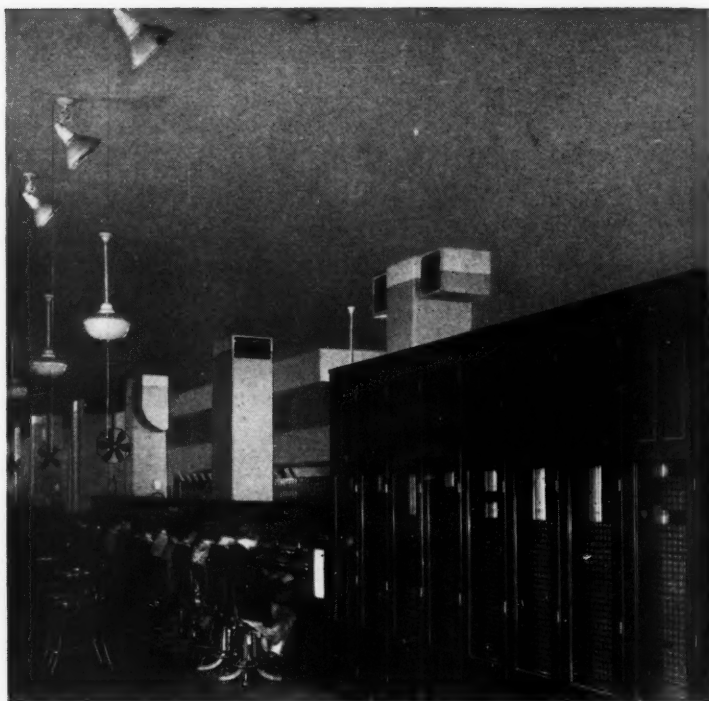


Fig. 4—For traffic registers, located in the operating room, special flood lighting is provided

tion is reduced to some extent.

In those parts of the switchrooms where the main switching units are installed there are almost always overhead structures which would make indirect lighting difficult, and in addition there is the need for much higher intensities. For these reasons the lighting of such places is of the direct type, generally with mirrored or prismatic glass reflectors. A typical installation is shown in Figure 2. The units are designed to throw all the light down and along the equipment frames on both sides of the aisle. In this way a moderately high intensity is provided for the necessary inspection and adjustment work.

Another form of lighting for somewhat similar work is that used for main frames. Very commonly main frames have a mezzanine platform

half way up as an aid to maintenance work on the upper half of the frame. In such installations angle mirrored reflectors are mounted in metal protecting troughs which run along the aisles just beneath the platform to light the lower part of the frame, and at a convenient height above it to light the upper half. A typical installation is shown in Figure 3.

When the platform is omitted, prismatic glass reflectors are located opposite the top shelf which throw light directly on the lower shelves of the frames and by transmission

through the glass, on the upper shelf. These reflectors also are of the angle type—one row being hung to light each side of a frame.

Special forms of illumination are sometimes required for particular needs. Register racks, for example, on which are mounted large numbers of traffic registers, require a high intensity for accurate reading, but the light is needed only when the registers are read. To meet these requirements a special flood lighting unit is employed—shown in Figure 4—which is only turned on for the periodic reading. The units are of a focusing type with mirrored reflectors and with control rings to keep the light from spreading. They are mounted so that when an operator stands in front of the racks no shadows will be cast on the registers being read. Traffic reg-

isters are usually mounted in the operating room where the inconspicuousness of the flood lights mounted close to the ceiling is of importance.

In addition to the regular lighting which is fixed in position, provision is made for temporary and more varied demands. Along the base of all frames, racks, and at switchboards, outlets are usually run to which extension lamps may be connected for work of a temporary nature such as repair or inspection. In addition flashlights are available for brief periods of inspection. In providing satisfactory lighting the aim has been to provide standardization, so as to obtain its resultant economies, and yet to allow sufficient variety to meet satisfactorily all possible needs.

Correctness of design, however, does not always insure that a lighting system will give satisfactory illumination throughout its life. Certain local factors of maintenance and operation are of paramount importance. The lamps are designed to operate at a definite voltage and at that voltage will radiate their correct quota of lu-

minous flux. Radiation, however, varies greatly with the voltage so that a reduction of only 10% in voltage will cause a decrease of 33% of the light emitted. Even though correctly designed, therefore, a lighting system may become unsatisfactory merely because the proper lamps are not used.

Another factor of considerable importance, particularly where the lighting is semi or totally indirect, is the color condition of the wall and ceilings. The amount of light reflected varies over a wide range with the color of surface. White will reflect about 85% of the light falling on it whereas a grey or tan color may reflect less than 50% of the light. Between these the range is continuous with variation in color and shade. It is important, however, not only to have the walls and ceilings of the proper color at the beginning but to have them maintained in good condition. Dirt rapidly darkens the surfaces and greatly cuts down reflection. To attain satisfactory illumination correct designs must be followed up by adequate maintenance.

The Holding Time Recorder

By R. I. D. NICOLL
Local Systems Development

IN making his plans for future central office equipment, the traffic engineer seeks to have enough circuits of each kind to handle the busy season load without an undue surplus of plant with its accompanying fixed charges and maintenance costs. To plan intelligently for the future, as well as for the efficient operation of existing plant, he must have records indicating by classes of service and trunk groups the rate at which calls originate and the average duration of these calls.

Since the quantities of certain central office circuits, such as cords, trunks, and selectors, depend directly on their holding time, holding time data are important. This information can be secured in several ways, such as from service observations or by actually timing calls with a stop watch. These methods, however, are not entirely satisfactory because of their slowness and the labor involved. Holding-time recorder equipment was accordingly developed to collect large quantities of data quickly and economically. This development was stimulated by the introduction of dial offices in the Bell System family of telephone exchanges.

The count of calls is taken in manual offices by the operators and in dial offices by registers directly associated with the circuits. To obtain the average duration, or holding time, of calls it is necessary, of course, that a suffi-

cient number of observations be made to establish a satisfactory average. Experience has shown that such an average may be obtained in a relatively short time from a comparatively small number of the circuits. Consequently it is unnecessary to install on a permanent basis equipment which is suitable for making holding time records. Temporary installations are therefore made, and in order to facilitate such installations, the equipment required for 10 recording circuits is assembled in a portable cabinet known as the 1-B Holding Time Recorder.

The recorder is equipped to make simultaneous observations on ten circuits. For each recording circuit, there are two registers and one key besides the usual equipment behind the scenes such as relays and resistances. The arrangement of registers and keys is shown in Figure 1.

The upper register records the number of times, and the corresponding lower one the total amount of time, that the associated circuit is in use. By dividing the total elapsed time, indicated on the lower registers, by the number of calls, indicated on the upper registers, the average holding time for the circuits under observation is obtained.

The lower registers, which indicate the elapsed holding time, are connected to the regular central-office clock circuit for their impulses. These

are repeated every six seconds so that the elapsed time is recorded in units of tenths of a minute, much as the speedometer on an automobile records distance traveled in tenths of a mile. Since the timing impulses are received regardless of the instant of the start of any one call, an error may result in the recorded holding-time of this call, but these errors to a large extent offset each other. A sufficient number of calls are usually observed so that the percent error is negligible.

With the I-B holding time recorder, it is possible to take readings on practically all types of circuits for which records are required. This includes

most of the circuits used in the various types of central offices, such as trunks, selectors, cord circuits, and toll lines. Readings are usually taken only on a part of the equipment available to obtain the different data required. Such data are regarded as indicative of the performance of the whole group or type of circuit involved.

Connections to the recorder are made to terminals located in the bottom of the cabinet by means of circuit extension cords shown in Figure 2. Besides the connection to each circuit to be observed, a few power connections are required including the interrupted timing circuit. Only a single-conductor connection is necessary for each circuit on which readings are taken and this is made to a point in the circuit that will insure obtaining either a battery or a ground connec-

tion for the full time the observed circuit is in operation. Various standard circuits have definite places for this connection, but since there is such a variety of them, they will not be enumerated here.

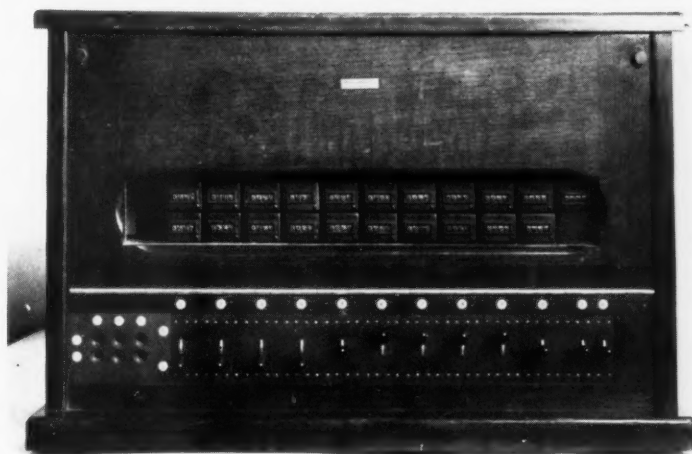


Fig. 1—Front view of I-B Holding-Time Recorder showing registers and keys

The recorder is so arranged that, if desired, dissimilar circuits may be observed at the same time. It is not possible to make connections to all circuits in the same manner. The recorder is therefore arranged to connect either battery or ground to any particular circuit as required. This is accomplished by means of the key associated with each circuit of the recorder, and key designation plates are used to indicate their direction of operation. These may be noted at the left of the row of key handles in Figure 1. The G on the bottom plate indicates that all the recorder circuits whose key handles are depressed, such as 1 to 4, are arranged to connect ground to the associated circuits. The letter B on the top plate indicates that all the circuits whose key handles are elevated, such as 6 to 9, are arranged

to connect battery to the associated circuits. Key handles 5 and 10 are normal, indicating that these are not functioning although they may be connected to some circuit.

In addition to the registers associated with each recorder circuit there are three others common to the recorder. One of these, known as the check register, is used to verify the accuracy of the clock circuit impulses or to measure the total time of one period of observation. This register is not in use unless the check register key, located at the right of the cabinet, is operated. The other two reg-

isters are normally located at the left of the cabinet in the space shown vacant in the photograph. One of these records the number of times all the circuits connected to the recorder are in use simultaneously, and the other records the elapsed time for such use. When all is ready to begin, the key at the extreme right is operated, and at the conclusion of the observation this key is restored to normal. The jacks shown in the lower left corner are connected by means of plugs and cords to portable key sets, shown in Figure 2, when it is desired to start each observation

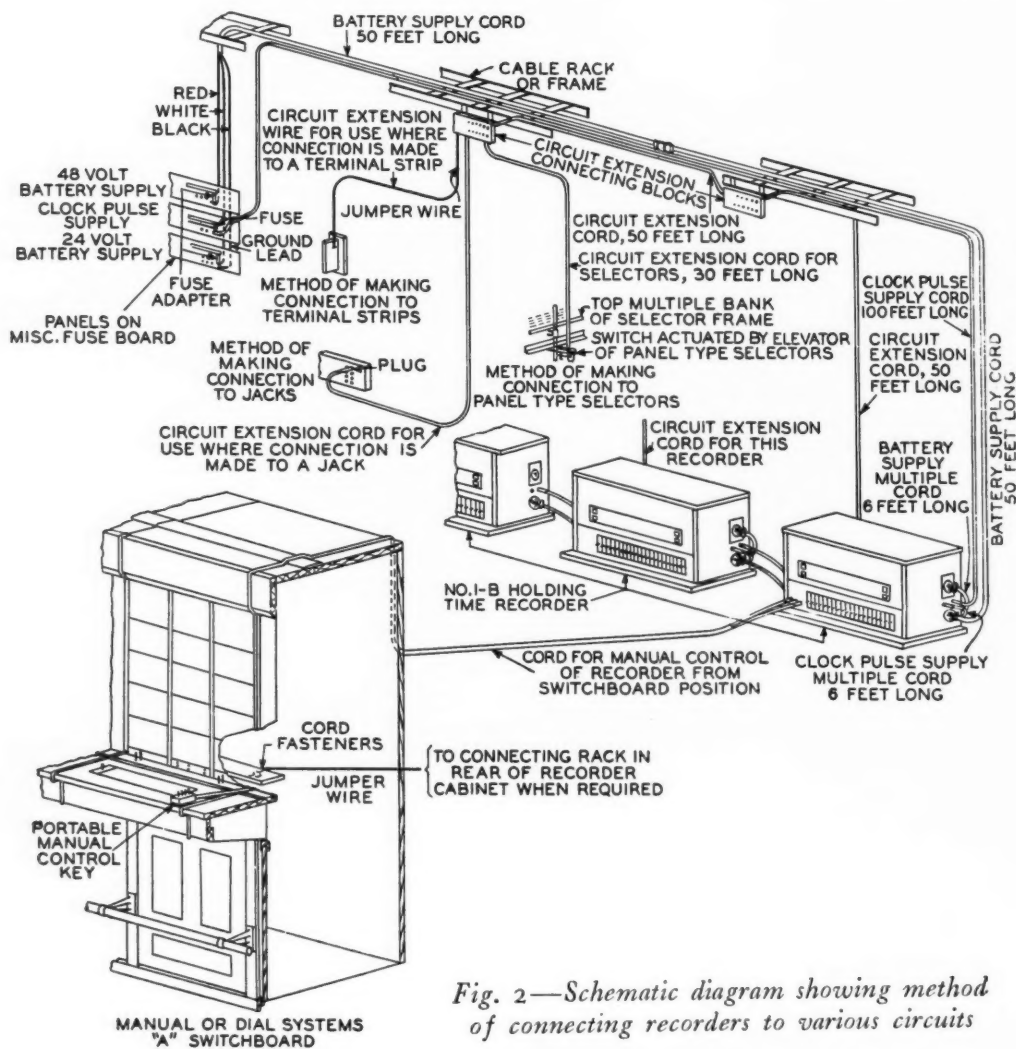


Fig. 2—Schematic diagram showing method of connecting recorders to various circuits

manually rather than automatically.

The upper part of both the front and rear of the cabinet is hinged so that it can be readily opened for adjusting the relays and registers. In addition, the entire back panel is removable to facilitate making connections.

The power connections to operate the recorder are made through the battery and clock-pulse supply cords, shown in Figure 2. Arrangements are made to multiple this supply to several cabinets by means of patching cords. The circuit extension and power cord arrangements are recent

developments of the equipment engineers and were made to facilitate making installations. Among these new developments is the switch shown in Figure 2, which is fastened to the bearing-plate and is operated by the brush holder of the elevator of the panel selector under observation. This avoids making any electrical connections to the selector circuit.

Weighing approximately 150 pounds and mounted in an oak cabinet, the 1-B Holding-Time Recorder is readily transported in a trunk, built for the purpose, to any central office whose traffic is to be studied.



Radio-Telephone Service with the Far East

As an initial step in its program of extending transoceanic telephone service into the Pacific region, the American Telephone and Telegraph Company has applied for a construction permit to erect a short wave radio-telephone station in California. This station is designed to connect the United States with various countries bordering the Pacific, and its island groups, as radio-telephone stations are equipped in the distant countries. As the demand for the service develops, Bell System telephones will be connected with one after another of the Far Eastern nations through a combination of land wires and short-wave radio transmission.

As now planned, the first regular service will be provided to the island of Oahu, in the Hawaiian group. In 1932 it is expected that all subscribers of the Mutual Telephone Company of Honolulu on the island will be within voice range of United States telephones. The radio station facilities at the Hawaiian end are to be provided by R. C. A. Communications, Inc.

Telephone administrations of other countries in the Pacific area have likewise expressed an interest in the proposed service. In time it is probable that direct telephone connections will be established with Australia, Japan and others of the more important far-eastern nations.

The Campaign Against Noise

THE average city dweller is continually submerged in an ocean of sound made up of squawking automobile horns, shrieking brakes, rumbling trucks, roaring subway trains, the rapid-fire of riveting machines, and the racket of radio loud-speakers. Such is the picture drawn by the New York City Noise Abatement Commission in its report, made public on July 15, which presented the results of a city-wide noise survey conducted under the direction of Dr. Harvey Fletcher by Dr. R. H. Galt, members of our Acoustical Research Department.

During the course of the survey, about 10,000 outdoor observations were made from a truck of the Health Department which had been equipped with sound-measuring apparatus by the Laboratories. Members of the Laboratories' staff who participated in this work under Dr. Galt were A. Meyer and K. P. Seacord, also of the Acoustical Research group, and T. G. Castner, H. Kahl, L. Y. Lacy, A. W. Treptow, and F. M. Carlisle, all of the Transmission Research group. Cooperating with them were J. S. Parkinson, C. W. Meyer, and J. Lenhardt of the Johns-Manville Corporation.

As a result of the survey, it was shown that the major sources of outdoor noises were trucks, automobiles, elevated trains, street cars and other agencies of transportation. Noises from building operations were second, often of greater intensity, but

less widespread in their effects.

From the results of the survey, it is hoped to take steps to reduce the noise evil, which was pictured in the first report of the Commission as greatly decreasing the vitality and efficiency of the citizens of New York. The first step in a program to reduce the noise of street traffic to a minimum was taken with the appointment of a committee of five manufacturers of automobile horns, who are to cooperate with city officials in drawing up specifications for horns which will give adequate warning without making unnecessary noise. Data will be furnished by the automobile horn tests conducted by Dr. J. C. Steinberg and other members of the Laboratories staff and described in the June RECORD.

Some of the figures obtained in the survey are of considerable interest. The most intense noises in the city were furnished by building operations, a riveter producing a noise level of 99 decibels above audibility, while the intensity produced by the use of explosives in subway excavation in the Bronx was 98 decibels. Such noises, however, were much more scattered than the ever-present roar of street traffic, which was found to vary from 50 to 80 decibels. Certain transportation facilities produced very intense noises. A subway express passing a local station produces a level of 96 decibels; a steamship whistle, slightly less; and elevated trains a level of 90 decibels.

NEWS AND PICTURES
of the
MONTH



Recording a Drama of Construction at Point Breeze

After arriving at the scene in the Laboratories' truck, R. E. Kuebler handles the amplifier and Walter Pritchard operates the camera. At the extreme left is C. W. Barrell, Western Electric motion picture director, and at the right is R. Van Luipen, chauffeur of the sound-picture truck

General News Notes

LIP READING BY TELEVISION TRANSMISSION

FOLLOWING satisfactory conversations with two guests who had employed lip reading to supplement impaired hearing, it was decided to arrange a telephonic conversation carried on by lip reading over the television system. The demonstration was conducted on July 2 in cooperation with the New York League for the Hard of Hearing.

Miss Evelyn Parry, national lip-reading champion who is unable to hear even ordinary conversation, sat in the television booth in the auditorium and conversed with her teacher, Miss Marie Pless, whose hearing in 60 per cent impaired. Miss Pless was in the television booth at 195 Broadway. The conversation was carried on with perfect understanding by means of lip-reading the television images.

In addition Miss Parry talked to press representatives and others at 195 Broadway. Conversation as rapid as ordinary telephone talk took place with the degree of success and failure usually attending lip-reading conversations. When she experienced difficulty in interpreting the word 'necklace' spoken by Howard W. Blakeslee, Science Editor of the Associated Press, Miss Parry explained that the word 'beads' lent itself more readily to interpretation by lip movements and was preferred in lip-reading conversations. With the exception of occasions when she requested

the Associated Press representative to move his head slightly to avoid shadows Miss Parry found little trouble in reading lip movements of the television image.

ORIGINAL 1877 SWITCHBOARD PRESENTED TO MUSEUM

ONE OF THE notable historical objects associated with the development of the telephone, the first exchange switchboard designed and used by E. T. Holmes in Boston in 1877, came into the possession of the Historical Museum on June 20. It was presented to the Historical Museum by his son, E. T. Holmes, Jr., of New York City. Formerly the switchboard remained in the designer's family.

The part played by the recently acquired switchboard in first interconnecting telephones is told in the recently published book "Beginnings of Telephony" by F. L. Rhodes which quotes from a speech delivered by T. D. Lockwood:

"In 1877 Mr. E. T. Holmes was carrying on an electrical burglar-alarm business at 342 Washington Street, Boston. He had a number of lines already in existence. Telephones were placed at the offices of a number of subscribers to this system, and by means of a switchboard, purchased for the purpose by Mr. Holmes, the lines were (connected) up on the 17th day of May, 1877, and thereafter repeatedly placed in intercommunication."

The recently acquired switchboard is shown on the opposite page.



The first telephone exchange switchboard is presented to the Laboratories' museum. Above, left to right, W. C. Langdon, Historical Librarian, A. T. & T.; Mrs. E. T. Holmes, Jr.; E. T. Holmes, Jr.; W. L. Richards, and W. C. F. Farnell. Below, the switchboard of six-line capacity

LABORATORIES DEVELOPMENTS TOLD IN MOUNTAIN STATES

ASSISTANT VICE-PRESIDENT S. P. Grace was in Helena and Boise and gave addresses and demonstrations on marvels of sound transmission. An audience of 3,000 crowded the Shrine Temple at Helena and listened with unabated interest as Mr. Grace ex-

plained and demonstrated with the assistance of R. M. Pease the call announcer, scrambled speech, the pocket microphone, artificial larynx and other developments of the Laboratories. While at Helena the Laboratories representatives were also luncheon guests of the Rotary Club. Mr. Grace spoke of unsolved problems faced by the scientist, mentioning

the abstruse nature of electricity, electrons and gravitation which, despite the ground already gained, contain vast territories that the scientist has yet to explore. Mr. Pease gave a short talk on sound pictures which was listened to with much interest. Another large audience was at hand in Boise when the talk and demonstration in the high school auditorium were again given. Both of these meetings in the Northwest were under the auspices of the Mountain States Telephone and Telegraph Company.

LABORATORIES MEN RECEIVE ACADEMIC DEGREES

AT RECENT commencement exercises at Cooper Union the following degrees were awarded to members of the Laboratories: B.S. in E.E., F. R. Bies, L. E. Milarta, L. J. Timm of the Apparatus Development Department, and George Hecht, W. L. Roehr, Jr., and F. W. Stubner in the Research Department. Degrees of B.S. in Ch.E. were awarded to V. J. Albano, R. A. Ehrhardt, H. A. Sauer, H. V. Wadlow of the Research Department and A. M. Mendizza of Apparatus Development. J. J. Hart was awarded the degree of B.S. in M.E. and W. F. Smith, Jr., the post-graduate degree of E.E. Both are members of the Research Department.

At the commencement exercises of Brooklyn Polytechnic Institute on June 18, R. R. Peterson of Apparatus Development Department received his degree in Electrical Engineering.

He was graduated with the highest grade in the evening course and accorded Cum Laude mention.

ADMINISTRATION



IN COMPANY WITH Dr. John H. H. Finley of the *New York Times*, Ambrose Swazey, scientist and philanthropist, Justice Frederick E. Crane of the Court of Appeals and other leaders in science, engineering and industry, Dr. Jewett was an honorary pall-bearer at the funeral of E. A. Sperry on Thursday, June 19. Dr. Sperry was noted for the invention of numerous devices employing the gyroscopic principle which have proved of great aid in air and water navigation.

On June 23, Dr. Jewett gave an address at the Commencement exercises at East Orange High School.

VICE-PRESIDENT H. P. Charlesworth and Assistant Vice-President S. P. Grace attended the Summer Convention of the American Institute of Electrical Engineers at Toronto.

ON JUNE 5, H. E. Shreeve, Technical Representative in Europe of the American Telephone and Telegraph Company and Bell Telephone Laboratories, returned to this country for conference with Bell System representatives. It is expected that Mr. Shreeve will remain in America for at least two months.

Departmental News

PERSONNEL

G. B. THOMAS attended the Montreal convention of the Society for the Promotion of Engineering Education, and read a paper entitled *An Experience in Industrial Education* before the Cooperative Engineering Education Division of the Society.

PATENT

TWENTY-FIVE YEARS with the Western Electric Company and the Laboratories were completed by H. G. Bandfield on July 5. Following his graduation from the University of Michigan in 1905 Mr. Bandfield entered the employ of the Western



H. G. Bandfield

Electric in the Clinton Street, Chicago, factory on the four-year contract course. Transferred to this building in 1907, he worked until 1915 in the physical laboratory on protection, coin-collectors and ringing systems. He then transferred to

the Patent Department where he has since been engaged chiefly on work pertaining to chemistry, protection and miscellaneous apparatus.

FROM March 1 to June 1, 1930, patents were issued to the following members of the Laboratories:

G. A. Anderegg	H. B. Johnson
C. H. Anderson	A. R. Kemp
S. E. Anderson	F. S. Kinkead
H. I. Beardsley	W. A. Knoop
B. G. Bjornson	F. A. Korn
H. S. Black	G. R. Lum
N. Blount (3)	F. S. Malm
O. E. Buckley (2)	W. A. Marrison
O. Cesareo	R. C. Mathes (4)
H. R. Clarke	J. M. Melick
T. H. Crabtree	C. R. Moore
T. V. Curley	E. C. Mueller, Jr.
A. M. Curtis (2)	J. B. Newsom
J. W. Dehn	A. A. Oswald
G. W. Elmen	G. C. Porter
S. H. Everett	W. T. Pritchard
W. Fondiller	T. E. Shea (2)
J. J. Gilbert (2)	W. F. Smith, Jr.
F. J. Given (2)	C. A. Sprague
R. M. C. Greenidge	J. C. Steinberg
F. Gray	R. L. Stokely
A. E. Hague	H. M. Stoller
H. C. Harrison	B. M. A. Trebes (2)
R. V. L. Hartley (2)	J. R. Weeks
E. E. Hinrichsen	J. F. Wentz (2)
F. A. Hubbard	H. Whittle (3)

DURING THE PERIOD from June 5, 1930, to July 2, 1930, members of the Patent Department visited the following cities in connection with the prosecution of patents:

Boston, H. A. Burgess; Washington, H. A. Flammer, I. MacDonald; Grand Rapids, G. H. Heydt, W. C. Kiesel; Wilmington, J. G. Roberts.

STAFF

TWENTY-FIVE YEARS of service with the Western Electric Company and the Laboratories were completed by C. A. Grant on July 8. Entering the employ of the Western Electric

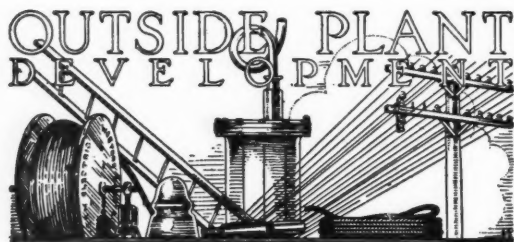
as his first job after leaving school Mr. Grant worked for a short period on transmitter assembly and then was transferred to the Model Room which then employed but half a dozen men. He was assigned to timekeeping, ordering of material and other miscel-



C. A. Grant

laneous clerical duties. In 1908 he was put on bench work where he worked on instrument and tool-making until 1916. From 1916 to 1918 he was in charge of a group making grids, plates and bases for vacuum tubes. After the armistice he returned to his work of instrument making. He became chief clerk of the plant department in 1923 and was assigned to his present work in charge of Plant Schedules in 1929.

ON JULY 5, Fred Wragg completed twenty years' service in Western Electric and the Laboratories.



D. A. QUARLES and S. C. MILLER

were on a trip through the middle west during the latter part of June. They visited Hawthorne and suppliers of Outside Plant apparatus in Minneapolis and Indianapolis.

THE ANNUAL meeting of the A. S. T. M. at Atlantic City, June 23-25, was attended by C. D. Hocker, F. F. Farnsworth and J. M. Hardesty.

ON A CONTINUATION of the program of tests on motor-vehicle finishes Mr. Farnsworth and L. H. Campbell were in Florida.

C. R. MOORE was in Hawthorne to attend a conference on the production of hand-rolling tools for making single-sleeve joints in line wire. While at Chicago he also went to M. Klein & Sons Company regarding the manufacture of linemen's climbers. Following this trip Mr. Moore went to Southington, Connecticut, to observe the manufacture of pliers at the Peck, Stowe and Wilcox Company and also visited the Reliable Manufacturing Company at New Haven in connection with the manufacture of warning signs, drop-wire reels, and strand dynamometers.

V. B. PIKE and F. D. WALDRON were at New Haven to observe the installation of a toll test terminal and a pressure alarm contactor.

E. ST. JOHN was in Atlantic City for the purpose of inspecting the cable shields which have been installed between Atlantic City and Philadelphia for a trial period of a year.

IN CONNECTION WITH general cable problems J. G. Brearley was at Hawthorne from June 3 to 6. With Mr. Richey and Mr. James of the A. T. & T. Co. he went to Joliet to observe the installation of some commercial cable having a new type of sheath.

E. C. WEGMAN completed twenty

years of service in the Bell System on July 11. He is now at Hawthorne working on current engineering.



MANUAL AND TOLL EQUIPMENT

J. A. MAHONEY visited Northern Electric at Montreal in connection with equipment for the connecting circuits of the transatlantic cable.

AN INSPECTION of the installation of a new type of magnetic busy signal in the toll office at Harrisburg was made by R. G. Koontz.

AT BRIDGEPORT J. W. Corwin was engaged in a study of the cabling features of the No. 2 Information Desk. A. G. Jeffery was in New Haven to investigate framework construction of the desk.

M. E. MALONEY visited New Haven and Stamford to look over several new features for the 740-A, 740-B and 740-C PBX's.

SPECIAL EQUIPMENT DEVELOPMENT

E. P. FELCH VISITED the ship-to-shore station at Forked River to arrange for the installation of additional power equipment for short-wave radio-telephone receivers.

THE INSTALLATION of additional voice-frequency equipment in the transatlantic radio-telephone transmitting station at Ocean Gate was supervised by L. A. Koehler.

R. H. MILLER attended the No. 3 toll and step-by-step dial cut-over at Worcester which took place over the

week-end of June 14 and 15. This Worcester cut-over was the largest cut-over of step-by-step dial equipment in the history of the Bell System, since there were approximately 45,000 lines transferred from manual to dial operation.

G. M. GREEN visited Harrisburg to discuss with the Installation Department the trial installation of improved busy signals.

AT ALBANY, K. C. Wilsey attended a conference with representatives of the New York Telephone Company and the Installation Department regarding step-by-step preselector equipment which has been on trial for some time at Syracuse.

L. P. BARTHELD made a trip to Chicago to supervise the installation of equipment to provide for improved signals between the toll tandem and line boards in the Chicago Toll Office.

A TRIAL INSTALLATION of new relays for gain control equipment was made under the supervision of G. M. Deyoe at Kingston.

POWER DEVELOPMENT

IN A CONTINUATION of his study of power plant noise on telephone circuits M. A. Froberg visited Cleveland, Wilkes-Barre, and Wanakah, New York.

V. T. CALLAHAN has been in Buffalo testing new radiator units for gasoline engines.

H. M. SPICER visited the General Electric plant at Fort Wayne in connection with the emergency alternator which will be used to furnish power to busy signals in case of outside power failure.

ON MATTERS pertaining to power-plant development R. L. Lunsford visited Hawthorne and inspected the new toll boards at Milwaukee and

Detroit. He also discussed several power-plant questions with the Aluminum Company's engineers at Pittsburgh, Pennsylvania.

LOCAL CIRCUIT DEVELOPMENT

ARTHUR RAYNSFORD completed a quarter century's service with the Western Electric Company and the Laboratories on July 3. Graduating from the University of Rochester with the A.B. degree Mr. Raynsford became a member of a special student course of the Laboratories and started in work in the present building, which then was owned and operated by the Western Electric Company. Until 1908 in the cable plant department he was engaged in special work on capacity unbalance. He was sent to Hawthorne and worked a year on engineering inspection and then transferred to equipment engineering. In May, 1915, he returned to New York and worked until 1921 in the circuit laboratory on analysis of Hawthorne orders. He has been engaged on his present work on panel circuits for the past nine years.

THE THIRTIETH anniversary of R. Raymond's association with the Bell System occurred on July 10. Follow-

ing his graduation from Cornell with an M.E. degree Mr. Raymond entered the engineering department of the Western Electric Company where he had an important part in development of early common-battery circuits. He was identified with panel switching developments from the outset. One of his major contributions during the early panel stages was the preparation of a key sheet for each job to specify the circuits necessary to meet individual traffic requirements. In the laboratory study of the coordinate system, Mr. Raymond was responsible for development of operative circuits. He has also had a prominent part in the perfecting of the decoder. At the present time his activities are concentrated on sender development.

W. H. MATTHIES returned to the Laboratories on July 9. During a ten weeks' tour he inspected telephone operations and engineering in nine countries of Europe.

L. J. STACY and H. E. POWELL visited Hartford in connection with the work of a committee to determine what improvements may be effected in subscriber station operation.

LINE-FINDER OPERATION in local step-by-step offices was investigated by T. L. Dimond at New Haven.

P. R. GRAY with Mr. G. H. Downes of the A. T. & T. Company, visited Montreal to discuss the operation of traffic registers with representatives of the Bell Telephone Company of Canada and the Northern Electric Company.

F. K. Low was in Atlanta where he spent several days investigating cir-



A. Raynsford



R. Raymond

cuit conditions in local central offices.

SEVERAL TRIPS to Springfield, Massachusetts, to conduct tests on a trial installation of two-party message rate trunks were made by W. J. Lacerte. He was also in Worcester to investigate matters pertaining to subscriber line cutoff relays.

L. M. ALLEN was in Pittsburgh with S. F. Butler to inspect some final selector circuit wiring and arrangements.

H. S. SHOPE visited Philadelphia to investigate emergency alarm systems in local telephone offices.

A. W. HORNE was in Chicago and later went to Seattle in connection with improvements in panel sender test circuits.

H. B. NIENSTEDT went to Providence to discuss telephone grouping circuits with engineers of the New England Telephone and Telegraph Company.

TOLL CIRCUIT DEVELOPMENT

J. MESZAR returned this month from Detroit where he spent several months as resident engineer in connection with the installation of the new No. 3 toll office.

TESTS ON toll subscribers' lines were made by T. V. Curley on a several days' visit in St. Louis.

L. F. PORTER and J. B. SHIEL were at Worcester, testing certain features of a new No. 3 toll switchboard placed in service June 14, 1930.

AT CHICAGO tests on a trial installation of a new method of signaling from a toll tandem switchboard were made by A. G. Lang.

TELEGRAPH DEVELOPMENT

C. B. SUTLIFF is in Denver in connection with a trial installation of pilot channel equipment to be used

with open-wire carrier telegraph systems. He is also devoting a considerable amount of time to the study of lightning interference in open-wire carrier telegraph systems.

A. M. KOERNER is still in El Paso on field studies of lightning interference in open-wire carrier telegraph systems.

TWENTY YEARS of service with the Western Electric Company and the Laboratories have been completed by Andrew D. Dowd on July 1.

CARRIER AND REPEATER DEVELOPMENT

W. F. KANNENBERG returned recently from Key West and Havana where in cooperation with J. T. Dixon of the A. T. & T. Co. he conducted an investigation of noise and interference preparatory to the development of carrier-telephone terminating circuits for the new Key West-Havana telephone cable.

E. P. CORDRAY, with H. A. Etheridge of the A. T. & T. Co., tried out a laboratory model of a new type of two-wire telephone repeater at the repeater station at Princeton, New Jersey.

DIAL EQUIPMENT DEVELOPMENT

S. F. BUTLER and H. E. MARTING, accompanied by several representatives of the A. T. & T. Co., visited Atlantic City to inspect an improved supporting structure which is being introduced on step-by-step equipments.

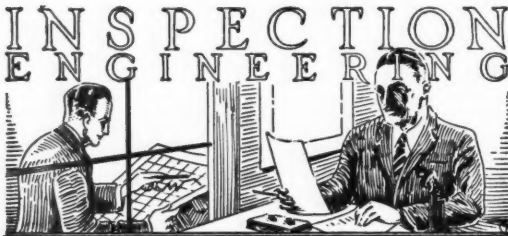
STEP-BY-STEP developments required E. J. Kane's presence at Hawthorne. He was also at Boston to discuss several orders being placed by the New England Telephone and Telegraph Company for Community dial equipments.



H. F. Dodge using a specially-devised wheel to show the workings of probability. Its markings represent the expected results for a sample of 265 pieces drawn from a lot 3 per cent defective

R. E. NOBLE and several members of the A. T. & T. Company visited Bridgeport to inspect an improved mezzanine platform for use in connection with main distributing frames.

STUDIES OF alarm equipment occasioned a visit of N. H. Thorn to Springfield, Massachusetts.



DURING THE latter part of June, H. F. Dodge and W. A. Shewhart attended the meeting of the A. S. T. M. special committee on Presentation of Data, of which Mr. Shewhart is chairman, held at Atlantic City. Mr. Dodge led the discussion of a topic presented by him on *How Large a Sample?*

J. H. SHEPARD left during the

early part of June to assume the duties of Field Engineer in the Atlanta territory. J. A. St. Clair accompanied Mr. Shepard to introduce him to the Southern Bell and Western Electric Company people in this territory. T. L. Oliver, who was formerly Field Engineer in Atlanta, returned to New York with Mr. St. Clair. Later in the month Mr. Oliver spent a few days in Boston with Mr. Dalton and one in New Haven with Mr. Edwards preparatory to assuming the duties of Field Engineer in those areas.

R. C. KOERNIG visited Fargo, Minneapolis and Fort Dodge in connection with rou-

tine investigations.

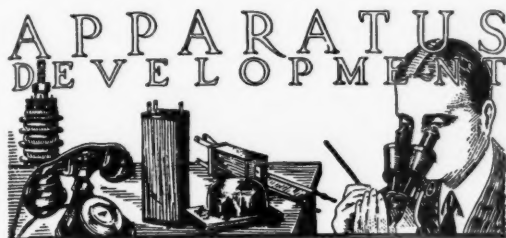
C. A. JOHNSON and H. G. EDDY spent a few days in Gary, Indiana, on special investigation work on step-by-step equipment.

GENERAL INSPECTION matters called W. E. Whitworth to Elyria and Akron, Ohio, and H. W. Nylund to Fresno, California, and Reno, Nevada. I. W. Whiteside visited Wilmington, Washington, Richmond and Baltimore while T. A. Crump was in Wilmington, Delaware, for a few days. In the same connection R. C. Kamphausen visited Indianapolis, Evansville, South Bend and Niles, Indiana.

H. K. FARRAR spent a number of days in Albany, Del Mar, and Pen Yan in connection with investigation work on Holtzer-Cabot Ringing Machines. He also visited Croton on a study of dial tone, and conducted a field survey on echo suppressors at Syracuse and Buffalo.

H. F. KORTHEUER was in Kearny

for a quality survey on No. 11 switch-board equipment. C. J. Hendrickson attended a similar survey on friction roll drives held at Hawthorne.



SPECIAL PRODUCTS

R. A. MILLER visited Hollywood and made a general inspection of a number of sound picture studios equipped with Western Electric apparatus.

L. B. COOKE tested the music-reproduction system recently installed in the Wyoming High School, Milburn, New Jersey.

VISITS TO THE Brooklyn Navy Yard to test equipment for sound pictures on naval vessels were made by G. C. Porter and R. A. Miller.

R. V. TERRY spent a week at Hawthorne to discuss with the Manufacturing Department various items in connection with sound picture apparatus.

TELEVISION was described in a talk before the Rotary Club at Kitchener, Ontario, by C. H. Rumpel.

K. O. THORP was in Louisville where he conferred with engineers of the Louisville Gas and Electric Company on problems relating to power-line carrier-telephone systems.

C. F. BOECK accompanied by H. A. Affel of the American Telephone and Telegraph Company visited Toronto to confer with officials of the Canadian National and Grand Trunk Railways on problems relative to their telephone communication service from moving trains.

RADIO DEVELOPMENT

B. R. COLE supervised the installation of a 1 kw radio telephone broadcasting equipment for the Monumental Radio Company at Baltimore. He also conducted a survey for the installation of a similar equipment for the Knickerbocker Broadcasting Company of New York.

H. E. J. SMITH and F. C. WARD directed the installation of a 50-watt and a 400-watt radio-telephone equipment for the Marine Division of the New York City Fire Department.

THE INSTALLATION of a 1 kw radio transmitter and associated speech input equipment for the WHB Broadcasting Company, Kansas City, Missouri, was supervised by J. F. Morrison. He also made a survey of the proposed location for a 1 kw radio-telephone broadcasting equipment and speech input equipment for the Coffeyville *Journal* at Coffeyville, Kansas.

F. S. BERNHARD has joined W. C. Tinus at Salt Lake City to assist in supervising the installation of Western Electric aircraft and ground radio-telephone equipments for the Western Air Express.

O. W. TOWNER inspected stations KVI and KGW owned respectively by the Puget Sound Broadcasting Company of Tacoma and the Oregonian Publishing Company of Portland.

SOUND PICTURE LABORATORY

W. HERRIOTT conferred with the Bausch & Lomb representatives at Rochester upon the design of densitometers for measuring the density of films.

R. M. PEASE, who has been with S. P. Grace on his lecture tour in the west, has returned from Hollywood

where he spent several weeks inspecting sound-picture studios equipped with Western Electric apparatus.

THE SOUND PICTURE Laboratory portable recording system on a Studebaker truck was used at Point Breeze to record construction activities of the new Western Electric plant. W. T. Pritchard and R. E. Kuebler operated the equipment under the direction of Mr. Charles Barrell, motion picture director of the Western Electric Company at 195 Broadway.

MATERIALS DEVELOPMENT

ON JULY 1 D. T. May completed twenty-five years of service with the Western Electric Company and the Laboratories. His career in the tele-



D. T. May

phone industry began in the Clinton Street factory in Chicago on the four-year contract course following his graduation from the University of Illinois with the B.S. in M.E. degree. He was transferred to New York in 1909 and worked until 1915 in the Physical Laboratory. During 1910-11 he was in charge of routine testing and from 1911 to 1915 he was engineer on design and test of electrical protection apparatus and systems. He was then made engineer on special

work, largely on design of special testing apparatus and protection devices, transmission tests on long telephone cables, and inductive interference from electrified railways.

In 1917 he was placed in charge of electrical analysis of apparatus and special protection systems. He assumed his present duties in 1926 in charge of mechanical and electrical analysis, design and test of electrical protective apparatus and systems and questions relating to inductive interference. He has served as Bell System representative on various committees on electrical protection.

VARIOUS COMMITTEE meetings at the A. S. T. M. convention at Atlantic City during the week of June 23 were attended by J. M. Wilson, J. R. Townsend, W. A. Evans, R. Burns, W. W. Werring, C. H. Greenall and C. H. Marshall. A paper written by J. R. Townsend and C. H. Greenall and entitled *Fatigue of Lead Cable Sheath Alloys* was presented at the convention. Earlier in the month Mr. Townsend was at Detroit to attend a meeting of the Spring Research Committee of the A. S. M. E. of which he is chairman.

IN HIS CAPACITY of consulting engineer for the War Department F. F. Lucas was at the arsenal at Watertown, Massachusetts, from June tenth to twelfth.

K. G. COUTLEE accompanied by Mr. R. Whitaker of the Hawthorne plant visited the Continental Diamond Fibre Company at Newark, Delaware, in connection with the development of a new fibre material for plug shelves.

F. M. NOLAN and J. J. MARTIN were at Hawthorne for a week on a general inspection tour devoted principally to manufacturing operations

connected with sealing compounds and sheet insulating materials.

I. V. WILLIAMS visited the plant of the Mattatuck Manufacturing Company at Waterbury and discussed material used in flat-type cable clips.

A. E. DIETZ and J. E. ROSS were in Nashville for two weeks working in cooperation with the National Electric Light Association on problems of inductive coordination.

C. E. NELSON was in Dallas, Texas and Huntington, West Virginia on his work pertaining to base-metal contacts. Also on base-metal contact problems E. Montchik was at Montreal and Atlantic City. L. E. Dickinson was also at Atlantic City on this work. D. W. Mathison was at Hawthorne where he discussed base-metal contact problems with Western Electric engineers.

SEVERAL TRIPS to the Pratt and Whitney plant at Hartford were made by R. O. Sloan to discuss flatness measurements on disks for oscillographs.

TRANSMISSION APPARATUS

ENTERING THE employment of the Western Electric Company in 1905 following his graduation with a B.S. in E.E. degree from the University of Illinois, E. B. Wheeler completed twenty-five years of service on July 1.

He started work in the Clinton Street factory, Chicago, on the four-year contract course and in 1907 was assigned to the Physical Laboratory of the Western Electric Engineering Department in New York City. A group of engineers doing

development work on telephone apparatus was placed under his supervision in 1909. During the war period, from April, 1917, to February, 1919, he was in temporary charge of the Physical Laboratory. In 1920 he undertook responsibility for the development work on telephone cords, switchboard cable, and insulated wire for central office use, switchboard lamps and dry cells and batteries.

Mr. Wheeler is one of the ten founders of Eta Kappa Nu, honorary electrical engineering society which was established during his undergraduate days at the University of Illinois in 1904. He is also a member of the honorary scientific societies Sigma Xi and Tau Beta Pi.

C. R. YOUNG's thirtieth year of service with the Western Electric Company and the Laboratories was completed on July 17. He began his career with the Bell System in the present building after graduating with a B.S. in E.E. from the University of Vermont.

Beginning work with the Western Electric as a final inspector of resistances, plugs, relays and census counters, he was given, a little more than a year later, the task of cataloging,



E. B. Wheeler



C. R. Young

checking and making sketches of gauges used in different shop departments. He did a good job at this and was later made designer of gauges for all new apparatus. Later he was made assistant foreman in charge of the final inspection of telephone and telegraph apparatus.

After filling this position for a little over a year he was transferred to the Detail Design section of the Engineering Department. In 1907 he was put in charge of this section where his work consisted in engineering such apparatus as transmitters, receivers, relays, drops and message registers manufactured at West Street. He remained in this position when the Chicago Design Engineering was brought to New York.

Here he worked for several years on the design of cable terminals and condensers. The "B" type cable terminal and practically all the paper and mica condensers used prior to the recent new series were designed under his supervision. In recent years Mr. Young has been engaged chiefly on loading coil cases, the present ones in use embodying many features of his design. The new series of arc-welded steel cases, replacing the cast-iron cases in use for nearly twenty-five years, were designed under his supervision.

ON JULY 15, R. L. Jones gave a luncheon in his office to Mr. Young, E. B. Wheeler and D. T. May in recognition of their many contributions to the telephone art made during their long association with the Bell System.

W. J. SHACKELTON and J. G. FERGUSON attended the annual meeting of the American Society for Testing Materials at Atlantic City.

E. B. WOOD and D. R. BROBST

were at Baltimore to observe the manufacture of lacquered wire.

P. S. DARNELL went to Hawthorne on work concerned with a special cable of high-current carrying capacity for high-frequency circuits. The cable is to be used in special retardation coils associated with the test transmitter at Bradley, Maine.

MANUAL APPARATUS

ACCOMPANIED BY C. A. Smith and K. Lutomirski of the Systems Development Department, C. F. Swasey visited the plant of the Weston Electrical Instrument Company in Newark to confer on special meters under manufacture for the Bell System.

DIAL APPARATUS

J. R. IRWIN visited the Trinity Exchange in Philadelphia to study results of a trial installation of contact protection for sequence switches.

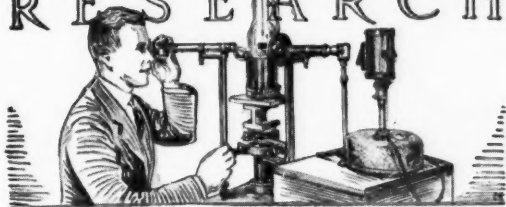
ACCOMPANIED BY representatives of the A. T. & T. Co., J. R. Fry was in Nashville for tests on telephone circuits paralleling high-voltage power lines.

TO OBSERVE special relay equipment, H. O. Siegmund visited the Automatic Switch Department of the Westinghouse Electric and Manufacturing Company at Pittsburgh.

TELEPHONE APPARATUS

COMPLETING a ten weeks' European tour, H. N. Van Deusen returned to the Laboratories on July 9. Mr. Van Deusen's mission took him into twelve countries, where he was engaged in the inspection of the various European telephone systems, and of manufacturing methods and equipment. In addition he made a general study of many materials which find a place in the telephone industry.

RESEARCH



AT THE MONTREAL convention of the Society for the Promotion of Engineering Education T. C. Fry gave a talk on the use of mathematics in industrial engineering and also read a paper prepared by John Mills entitled *Project Method in Research*.

AT THE ITHACA meeting of the American Physical Society, F. Gray presented a mathematical analysis of *Contact Resistance and Microphonic Action*. F. S. Goucher presented a paper on the same subject reporting his results of experimental studies which were a continuation of those previously reported at the April meeting of the society in Washington. At the Ithaca meeting A. R. Olpin also presented a paper *Inhibition of Photoelectric Emission by Near Infra-red Light*.

TRANSMISSION INSTRUMENTS

D. G. BLATTNER was at Grand Rapids as technical advisor to members of the Western Electric patent department.

W. C. JONES was at Hawthorne on development work to improve the strength of the shell and cap of the deskstand receiver.

MATTERS pertaining to handset receivers required H. A. Larlee's presence at Hawthorne for two weeks in June.

CHEMICAL LABORATORIES

THE FOLLOWING members of the Chemical group attended the A. S.

T. M. convention at Atlantic City: C. L. Hippensteel, L. A. Wooten, A. E. Schuh, J. H. Ingmanson and C. W. Scharf.

R. M. BURNS and H. E. HARING attended the meeting of the American Electrochemical Society at St. Louis.

WHILE VISITING his former home in Troy, Ohio, U. B. Thomas, Jr., addressed the local Rotary Club on recent developments of the Laboratories.

C. J. FROSCH and C. O. WELLS were at Louisville for two weeks on wood-preservation studies.

RADIO RESEARCH

W. WILSON, Assistant Director of Research, has been named on one of four committees appointed at a recent meeting in which representatives of communication companies and governmental departments interested in radio convened with the Federal Radio Commission. The several committees will deal with questions remaining unsolved at the adjournment of the Hague meeting of the C. C. I. on Radio last September. The committee of which Dr. Wilson is a member will study jointly the questions of perfecting methods for comparison of frequency standards and calibration of wave-meters. Other Bell System representatives on the committees are L. E. Whittemore and Lloyd Espenschied, both of the A. T. & T. Co.

THE DEPARTMENT of Commerce has issued commercial radio-operator's licenses to L. E. Hunt and T. J. Hickley of the Deal Beach station.

WALTER SHERMAN, foreman of building, grounds and outside plant work at the Deal Beach Radio Station, died July 7. At the time of his death Mr. Sherman was fifty years of age and had been with the Labora-



Heterodyne Audiometer used at the Central Institute for the Deaf in St. Louis. This audiometer, developed in the Laboratories, because of its great range of pitch and sound intensity, is capable of exploring the entire auditory sensation area, permitting the measurement of any degree of deafness. Miss H. G. Adams of the Medical Department and Miss Beverly Rice of the Publication Bureau show how it operates

tories since 1923. He was foreman in charge of the erection of antennas for the experimental tests at Deal Beach. Mr. Sherman was widely known as a leader, serving as fire chief, postmaster, and was active in fraternal affairs.

ACOUSTICAL RESEARCH

THE AMERICAN FEDERATION of Organizations for the Hard of Hearing held its eleventh annual convention at Hotel Roosevelt, New York City, June 16-19, at which Harvey Fletcher was reelected President. J. B. Kelly conducted an institute on Measuring Hearing.

On July 2 Mr. Kelly delivered a paper before the annual convention of American Association to Promote

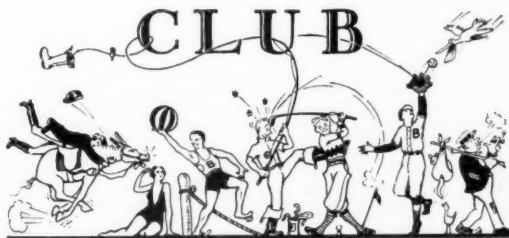
Teaching of Speech to the Deaf, held at Milwaukee. The title was *Physical Factors Affecting Instrumental Utilization of Residual Hearing in Education of the Deaf*.

SUBMARINE CABLE

ON JULY 1, O. B. Jacobs completed twenty years of service in the Bell System.

LABORATORY ENGINEERING

E. G. CONOVER visited the Bureau of Standards, the Westinghouse Electric and Manufacturing Company, Pittsburgh, General Motors Corporation, Detroit, and Eastman Kodak Company, Rochester, to discuss general service problems of research organizations.

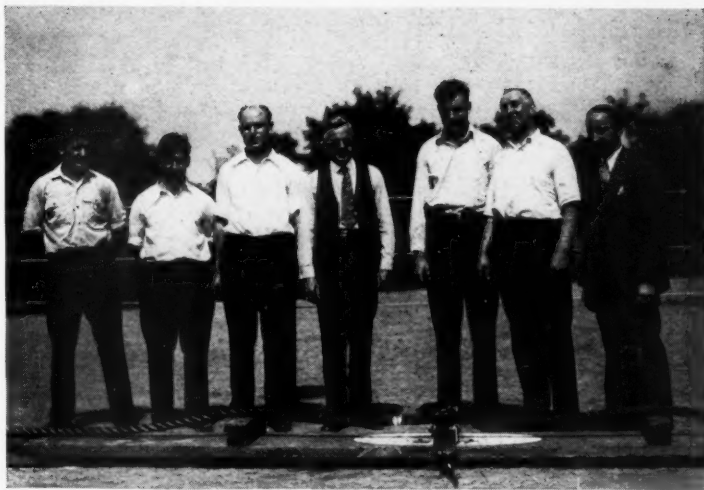


TRACK MEET

Whether inspired by the support of some four hundred rooters from the Laboratories or merely by the kindness of the weather man in providing a fair day, there is no question that the Bell Laboratories Club Team was inspired when they met the team of the New York Telephone Company,

Manhattan Area, in a Dual Track Meet at Erasmus High School Athletic Field on Saturday, June 28. Though outclassed by a slight margin in several of the speed events, the Laboratories' men were unquestionably superior in field events and in the tug-of-war, and saved their track laurels by winning first and second places in the 100 yard dash, second place in the 220 yard dash and first place in the 880 yard run.

The Laboratories' team won every place in the broad jump, high jump and shot put, scoring over half their total points for the meet in those three events. This ability in the field plus the victory in the tug-of-war was almost sufficient to defeat the New York Telephone Company without E. W. Sullivan's sensational 880 yard



The victorious Laboratories tug-of-war team. From left to right, W. Reichardt, W. Haffner, F. Pracknaich, W. Calmar, W. Kallensee, P. Healy, J. Kipp

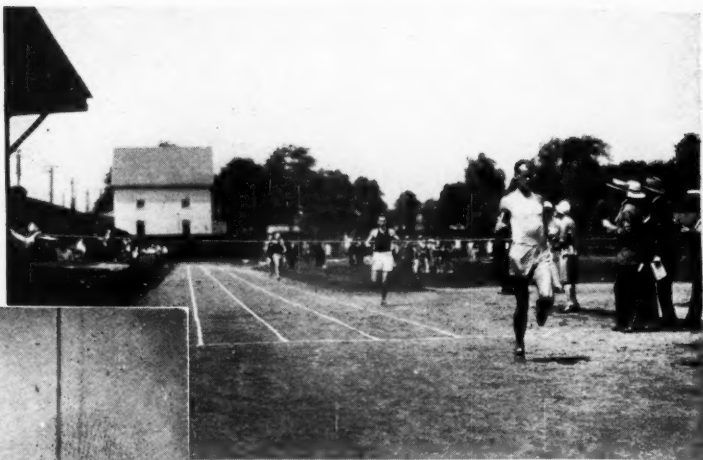
run in which he crossed the tape 30 yards ahead of the next runner, and the successes of L. S. Squires and Whidden in the other speed events.

The most thrilling contest of the day was the tug-of-war in which four of the five members of the Laboratories' team were veterans from last year's meet. In the trials they won by 16 inches, and in the finals took 8 inches from their opponents in the first minute and then settled down and held this advantage until the finish. The team was trained and managed by Bill Calmar who has coached the tug-of-war for the past six years.

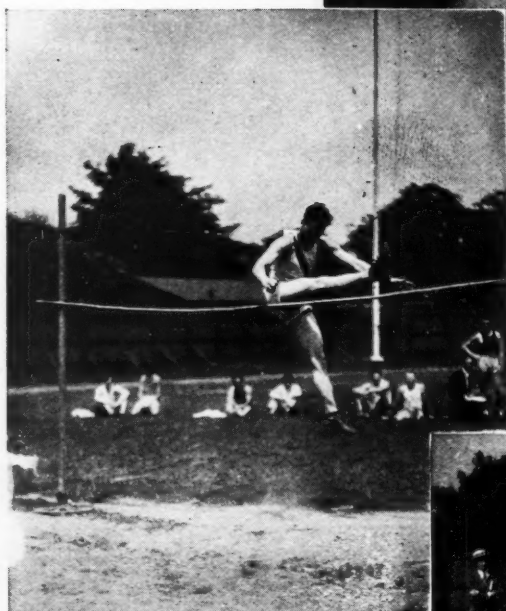
In the women's events the Laboratories Club did not fare as well as usual. For the first time in six years their team did not place in the 60 yard



C. E. Nelson won the shot put with a toss of 43 feet 1 inch



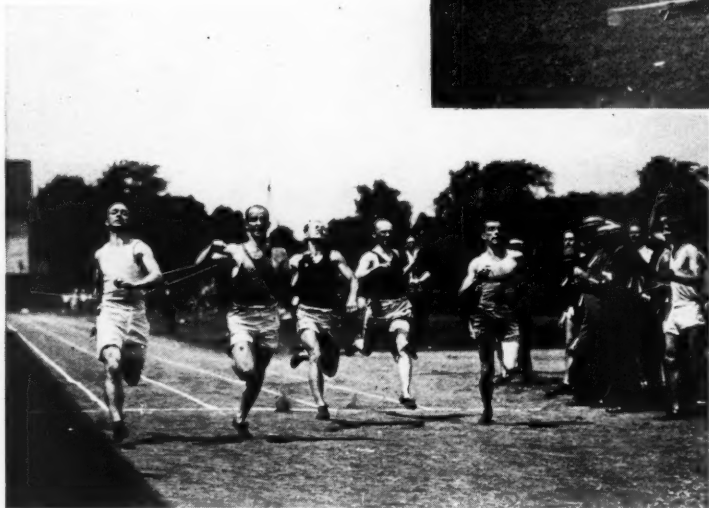
*E. W. Sullivan of B. L. C. winning the
eight-eighty*



*L. S. Ostermeir of B. L. C. tops
the timber for a first*



*Katherine Hildebrandt
hurled the baseball 177
feet*



*L. S. Squires of B. L.
C. winning the final of
the hundred*

dash. In the baseball throw, however, a first place was gained by Miss Hildebrandt's throw of 177 feet which was 20 feet farther than that of Miss Hacker of the New York Telephone Company, her nearest competitor.

L. P. Bartheld filled his old job as Chief Clerk of Course, getting the athletes to mark on time with his usual unequalled success. D. R. McCormack was Chief Track Judge, and Ken Doherty custodian of the

prizes. The coaching was done by Mr. and Mrs. W. Wallace.

The trophy for the men's events came to the Laboratories with a final score of 52 to 25. First place prizes for six of the nine events for men were awarded to our team. In the women's events the final score favored the New York Telephone Company by 17 to 9, giving them the women's trophy, but bringing one of the three first-place awards to the Laboratories.

EVENTS FOR MEN

- 100 yard Dash
 - Won by Squires, B. L. C.
 - 2nd—Whidden, B. L. C.
 - 3rd—Entwistle, N. Y. T.
- 220 yard Dash
 - Won by Tomford, N. Y. T.
 - 2nd—Whidden, B. L. C.
 - 3rd—Entwistle, N. Y. T.
- 440 yard Dash
 - Won by O'Brien, N. Y. T.
 - 2nd—Johnson, N. Y. T.
 - 3rd—Failla, N. Y. T.
- 880 yard Run
 - Won by Sullivan, B. L. C.
 - 2nd—O'Brien, N. Y. T.
 - 3rd—Johnson, N. Y. T.
- 1 mile Relay
 - Won by N. Y. T.
 - 2nd—B. L. C.
 - 3rd—B. L. C.
- High Jump
 - Won by Ostermeir, B. L. C.
 - 2nd—Kontis, B. L. C.
 - 3rd—Sperr, B. L. C.

Shot Put

- Won by Nelson, B. L. C.
- 2nd—Campbell, B. L. C.
- 3rd—Sperr, B. L. C.

Broad Jump

- Won by Pasanen, B. L. C.
- 2nd—Ostermeir, B. L. C.
- 3rd—Campbell, B. L. C.

Tug-of-War

- Won by B. L. C.

EVENTS FOR WOMEN

Baseball Throw

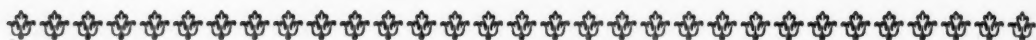
- Won by Miss Hilderbrandt, B. L. C.
- 2nd—Miss Hacker, N. Y. T.
- 3rd—Miss Mare, B. L. C.

$\frac{1}{4}$ mile Relay

- Won by N. Y. T.

60 yard Dash

- Won by Miss Rinaldi, N. Y. T.
- 2nd—Miss Hickey, N. Y. T.
- 3rd—Miss Morrissey, N. Y. T.



Contributors to this Issue

E. K. EBERHART received a B.S. degree in Mechanical Engineering from the University of Pittsburgh in 1924 and at once joined the Technical Staff of the Laboratories. Previous to graduation he had been with the National Tube Co. and the Westinghouse Electric and Manufacturing Co. in connection with the cooperative-work plan of the University. His first work at the Laboratories was with the trial-installations group of the Systems Department. For the past four years he has been engaged in equipment and miscellaneous development.

AFTER RECEIVING an A.B. degree from Acadia University in Nova Scotia in 1909, F. S. GOUCHER spent two years at Yale where he received the degrees of A.B. and M.A. The following year he went to Columbia as Research Assistant to Prof. Pupin and obtained his Ph.D. in 1917. He

was overseas with the British Expeditionary Forces and at the close of the war remained in England carrying on research at University College, London, under a grant from the Scientific and Industrial Research Council. Later he was a research physicist with the General Electric Company, Ltd. at Wembley. In 1926 he joined the Laboratories and since then has been engaged in the study of carbon contacts with reference to their behavior in microphones.

F. F. LUCAS entered the Hudson River Telephone Company, now a part of the New York Company, in 1902. Advancing rapidly, he held, during the next eight years, a number of supervisory and engineering positions in various operating companies of the Bell System along the Atlantic coast. In 1910, he became associated with the Western Electric Company, supervising the installation and inspection of power apparatus. Shortly



E. K. Eberhart



F. S. Goucher



F. F. Lucas



J. R. Townsend



A. M. Curtis



R. I. D. Nicoll

afterward, he became engaged in the study of the materials which enter into the telephone plant. Enlisting the microscope to his aid, he soon became a pioneer in the photomicrography of metals at extremely high powers. In recent years, he has begun applying the technique which he developed for metallurgical work to the study of medical and biological specimens.

AFTER GRADUATING from High School and spending a year at Heffley Institute in Brooklyn, A. M. CURTIS went to sea as wireless operator for the United Wireless Company. In 1910 he became chief operator, inspector, and installer for the radio systems of the Lloyd Brasileiro, a Brazilian shipping company operating some thirty ships. In 1912 he went up the Amazon on an exploring expedition of the Brazilian Department of Agriculture, his work being to keep in radio communication with the base. He joined the Western Electric Com-

pany the following year and in 1915 was in Paris for the Arlington-Paris radio telephone tests. Two years later he joined the army as Lieutenant in charge of inspection at the Signal Corps' General Supply Depot at Nevers, and later became a Captain in charge of the inspection section of the Division of Research and Inspection in Paris. He returned to the Laboratories in 1919 and since then has been working on the development of submarine cable and apparatus.

J. H. BELL was in South Africa with the Signal Corps of the British army during the Boer war and in 1902 went with the Engineering Department of the British Post-Office. He left to join the Western Electric Company at West Street in 1911. Since that time he has been with the Laboratories continuously, engaged in telegraph development work and such allied systems as picture transmission. At the present time he is in charge of telegraph development.



J. H. Bell

J. R. TOWNSEND joined the Engineering Department of the Western Electric Company in 1919. He was first concerned with the testing of telephone apparatus, but later he specialized in the development of testing methods and requirements for the materials which composed the apparatus. To further this work, he and the organization of which he is in charge have built up a remarkably complete laboratory and technique for the testing of materials.

AFTER GRADUATING from the School of Science and Technology of

Pratt Institute, R. I. D. NICOLL entered the Western Electric Company at New York in 1902. In 1905 he transferred to the Engineering Department of the New York and New Jersey Telephone Company which later consolidated with the New York Company. In 1913 he returned to the Engineering Department of Western Electric, which later became Bell Telephone Laboratories. Since that time he has been engaged in the design and development of toll and manual central-office circuits. At present he is engaged in Local Systems Circuit work.



Another Laboratory in New Jersey

A new laboratory will shortly be erected in Murray Hill. Property to the extent of 200 acres has been assembled in the block bounded by Mountain Avenue, Glenside Road, Glenside Avenue, and Diamond Hill Road, in the Borough and Township of New Providence. The principal frontage is along Mountain Avenue. Adjoining the Watchung Reservation on one side, the property extends to within about half a mile of the Murray Hill railroad station on the other.

It is proposed to establish on this site a laboratory for many of the problems in communication which can best be studied in the quiet atmosphere of the suburbs. Buildings as they are gradually erected will be of moderate height, and their architecture, as well as the landscaping, will not be out of harmony with the residential character of the neighborhood. No commercial manufacturing is proposed. Final decisions have not been made as to the first groups of scientists who will work there, but it is expected that plans will progress far enough to allow ground to be broken in the autumn.

